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This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists by disclosing interesting information well in advance of the usual scientific publications.

The articles are written primarily by members of the staff of ONRL, with certain articles prepared by, or in cooperation with, members of the scientific staffs of the United States Air Force's European Office of Aerospace Research

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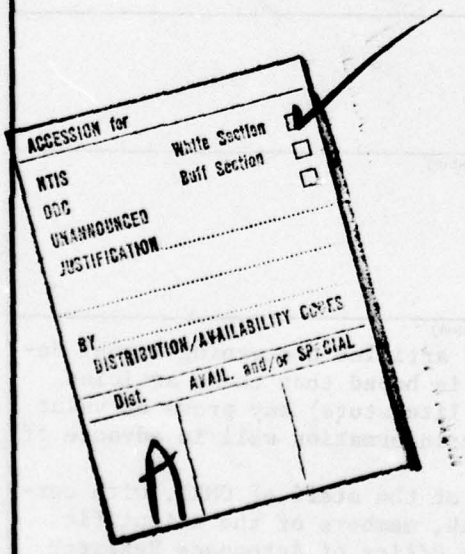
20. ABSTRACT (Continued)

and Development and the United States Army Research and Standardization Group. Articles are also contributed by visiting Stateside scientists.



EUROPEAN SCIENTIFIC NOTES
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Edited by William J. Gordon and Victoria S. Hewitson

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CHEMISTRY

VISIT TO THE DEUTSCHE GESELLSCHAFT FUR CHEMISCHES APPARATEWESEN

The Deutsche Gesellschaft für Chemisches Apparatewesen e.V., known as Dechema, is a German organization without a counterpart in other countries. The functions of this non-profit organization are research and training in various areas of chemical engineering and the materials sciences, and the dissemination of information in these areas. Dechema's activities are unusually extensive and include the following:

1. Dechema Institute, which carries on research in various areas of applied chemistry, materials sciences and corrosion.
2. Dechema courses for scientists and engineers from the chemical industries and chemical equipment manufacturers.
3. The Max Buchner Research Foundation, which sponsors 70 research projects in chemical engineering and allied areas in Europe.
4. ACHEMA, the European meeting of chemical engineering and the exhibition congress in chemical process engineering and related areas, held every three years in Frankfurt.
5. National and international committees on standardization of laboratory equipment, corrosion, chemical documentation and other specialized areas related to chemical processing, surface protection, disposal of industrial waste, materials for chemical equipment, and industrial biochemistry.
6. The European Federation of Chemical Engineering and Corrosion, administered by Dechema.
7. The Dechema prize and medal for outstanding scientific achievement.

Dechema has a large number of publications which include: the ACHEMA Yearbook; Dechema Monographs, the complete texts of the lectures at the ACHEMA Congresses; Dechema Tables of Materials: [(1) Chemical Resistance of Materials, (2) Physical Properties of Materials]; Dechema Reports on the Exchange of Experience, which provide the applied chemist practical information on filtration, vacuum techniques, vapor pressure tables, etc.; Literature Searches, a subscribers' service gathering information from 450 periodicals in the chemical engineering and corrosion area--including Dechema's *Thesaurus of Chemical Engineering*; and news bulletins issued bimonthly on Dechema activities.

In addition Dechema acts as the co-editor of *Chemie Ingenieur-Technik, Werkstoffe and Korrosion* and *Zeitschrift für Werkstofftechnik*, printed by Verlag Chemie, GmbH.

Founded in 1963, Dechema has its own facilities in Frankfurt for teaching courses in various engineering and materials sciences areas including laboratory instruction, and for carrying out research in these areas. In its laboratories, a number of experiments and demonstrations are set up permanently for instructional use.

Dechema supports its many activities through individual and company membership fees and grants for projects from government and industrial sources.

Under the directorship of Professor Dieter Behrens, Dechema has specialized in research in the following areas with the size of the working groups in each of these areas indicated in the parentheses: Chemical Engineering--Chemical reaction technology (7); Physical measuring techniques (5); and Industrial biochemistry (3). Materials and Corrosion--Materials behavior (15); Electrochemistry (11); High temperature corrosion (5); and Corrosion testing (1).

In September of this past year, the author visited the electrochemistry group which is headed by Professor Ewald Heitz. This group has emerged as one of the more prominent working in electrochemistry in Germany. The research in progress covers electrochemical engineering, studies of flow-through and fluidized-bed electrodes; the electro-reduction of carbon dioxide; the corrosion of aluminum and other metals in aqueous and non-aqueous electrolytes, including organic acids and halogen compounds; erosion-corrosion of metals; and high temperature corrosion of alloys in molten sulfates. (Ernest Yeager, Dept. of Chemistry, Case Western Reserve Univ., Cleveland)

COMPUTER SCIENCE

EURONET--EUROPEAN ON-LINE INFORMATION NETWORK

After several years of experience with an experimental computer network called the European Information Network (EIN) and two years of Ministerial-level planning and publicity, the Commission of the European Communities (EEC) is on the verge of going "on-line" with EURONET--a Community-wide computer network for the direct access of scientific, technical and socio-economic data via dial-up teletype or alpha-numeric display terminals. According to Mr. David Buckley, the EEC's Directorate General for Scientific and Technical Information, by mid-1978 EURONET will provide access to approximately 100 data bases. The network will be financed by Community funds, with an investment of 3 million "European units of account" (~$4 million) allocated for the period up to the end of 1977.

The need for such a European-wide network has been documented to the apparent satisfaction of all nine of the Member countries whose respective Post, Telegraph and Telephone (PTT) Administrations are responsible for the creation of domestic information networks which meet the agreed-upon international standards. As an indication of this growing need, an EEC-commissioned study in 1974 reported that in the United States, where information networks are becoming rather commonplace, the rate of on-line queries had increased 10-fold in a three-year period. It is estimated that by 1980 there will be a European demand for some 2 million such queries per year to technical and scientific data bases, and that this number will double by 1985. Although both private and public information services in each of the Member countries are attempting to respond to this demand, the Community proponents of EURONET argue that more efficient and cost-effective access to data bases on an international level is required to achieve economic viability. It is also hoped that the communications network developed for EURONET will serve as the starting point for an international public data-transmission network that the PTT Administrations will implement within the next decade, cf. the article on the UK's Viewdata and Teletext systems by N.M. Blachman in this issue of ESN.

Initially, the network will consist of four switching nodes at Frankfurt, London, Paris and Rome, and five remote concentrators at Amsterdam, Brussels, Copenhagen, Dublin and Luxembourg. A PTT-operated control center will be responsible for network management and accounting. EURONET will employ what is termed "packet-switching technology" which provides telecommunications advantages such as efficient line usage, high reliability, well-defined interfaces and easy adaptation of non-compatible host computers and user terminals. It is claimed that the network's performance requirements should ensure 200 hours mean-time-between-failure and an average response time of 1-3 seconds, excluding data processing time.

To date, more than 20 data base operators offering over 100 data bases have announced their intention of joining EURONET which, in principle, is open to operators and users from both the public and private sectors. Two of the larger data bases which are to be available are the Space Documentation Service (SDS) of the European Space Agency and the Deutsches Institut für Medizinische Dokumentation and Information (DIMDI). The EEC itself is fostering the development of community-wide data bases in central subject areas and, in December, installed a Siemens 7.740 host computer in Luxembourg which will offer the EURONET user information on EEC economic data and legal agreements.

In view of the apparent demand, the availability of the technology and the benefits to the Member countries, the success of EURONET seems certain until one recognizes that it is not starting in a vacuum, but in what its supporters refer to as "a complex landscape of emerging data and information networks." Less euphemistically, EURONET is starting in a communications jungle of already existing private information services and new public data networks such as TRANSPAC (France), Experimental Packet Switching Service (UK) and the circuit-switched services in Denmark and the Federal Republic of Germany. The extent to which this labyrinth of telecommunication equipment, computers

and data bases can and will be interconnected within the supranational, EEC-sponsored EURONET remains to be seen. (William J. Gordon)

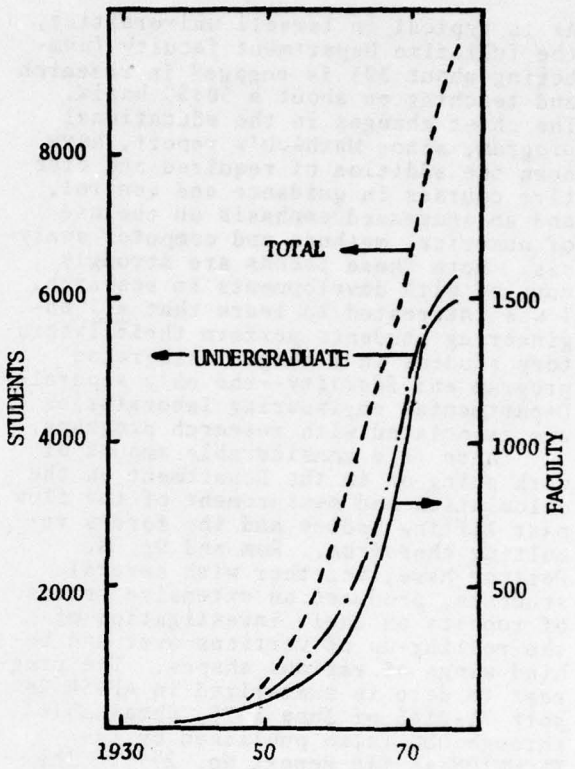
ENGINEERING

FURTHER OBSERVATIONS ON ENGINEERING RESEARCH AND EDUCATION AT THE TECHNION

In the period following the establishment of the State of Israel in 1948 until the beginning of the '70s, the number of students in institutes of higher learning grew by a factor of 22, almost an order-of-magnitude faster than the growth of the population. About 8 out of every 10 young people in Israel continue their studies beyond the high-school level. Statistics such as these, of which there is an abundance, clearly show that in Israel there is a commitment to education. The TECHNION (Israel Institute of Technology, Haifa) is a testament to this commitment and has attracted much attention from educators and researchers throughout the world.

The history and institutional personality of the TECHNION are reviewed in the 1971 report by R.D. Mathieu (ONRL R-15-71). The picture at the TECHNION has changed considerably since then, as indicated by the student and faculty levels given in the graph below.

There has been exponential growth in student enrollment and, until very recently, this has been closely tracked by corresponding increases in faculty. Since the early '70s, however, the major growth has been in graduate-student enrollment, and the increase in faculty has come to an almost screeching halt. Interestingly enough, the student enrollment numbers at the TECHNION, if displaced by about 10 years and expressed in millions instead of thousands, are not unlike the US statistics (from 232,000 undergraduates in 1930 to 5.5 million in 1966). The rates of increase at the TECHNION have been even higher, however, and there is a good deal of worry that non-growing pains are in store for Israeli higher education.



The purpose of my visit to the TECHNION was to learn of current developments in fluid mechanics and related areas. This took me to the Department of Aeronautical Engineering with short stops in Mechanical and Civil Engineering. The chairmanship in Aeronautical Engineering rotates among the senior faculty, and my host there was Prof. J. Rom who indicated that he was about to be relieved--an apt choice of words for the process of replacing department chairmen. Rom, a graduate of Caltech, described the rather sudden approach to steady-state within the Aero Department where there are now about 340 students in the 4-year undergraduate program and about 180 graduate students, 25 of whom are seeking the Doctor of Science in Technology degree. (The basic DSc degree is for science graduates--there are no PhD degrees awarded at TECHNION). About 2/3 of the graduate students are part-time. There is a full-time staff of about 40, and this is augmented by 15-20 engineers from industry who hold part-time appointments.

As is typical in Israeli universities, the full-time Department faculty (numbering about 30) is engaged in research and teaching on about a 50:50 basis. The chief changes in the educational program, since Mathieu's report, have been the addition of required and elective courses in guidance and control, and an increased emphasis on the use of numerical methods and computer analysis. Both these trends are strongly coupled with developments in research. I was interested to learn that all engineering students perform their laboratory studies in a single integrated program and facility--the only separate Departmental engineering laboratories are associated with research programs.

There is a considerable amount of work going on in the Department on the calculation and measurement of the flow past lifting bodies and the forces resulting therefrom. Rom and Dr. H. Portnoy have, together with several students, produced an extensive series of reports on their investigation of the rolling-up of vortices over and behind wings of various shapes. The progress to date is summarized in AFOSR Report 71-2145 of June 1976, obtainable through DDC (also published by the TECHNION as TAE Report No. 277). The work is based upon the Vortex Lattice Method in which the lifting surface is modeled by a vortex distribution. The extensions provided by Rom and his coworkers include the treatment of low-aspect-ratio wings and other highly three-dimensional configurations in which the rolling-up of the vortices contributes important and non-linear terms to the overall wing performance. For a variety of vortex distribution and shedding criteria, quantities such as vortex strengths, shapes, and trajectories are calculated as well as wing aerodynamic coefficients, and these are generally found to be in good agreement even for highly non-linear (low-aspect-ratio) conditions. The development of secondary vortices is successfully modeled in many cases. The current work in this area is aimed towards generalizing the computer program for arbitrary wing shapes, and including the effects of camber, lift augmentors, and thickness.

Along similar lines, Dr. J. Shinar has been working with Rom and his graduate students to analyze flows associated with finned bodies-of-revolution. Shinar's main interest has been in the prediction of forces induced by the flow past canards mounted on missile-like bodies with tail fins, [*Israel J. Tech.* 14, 74-85 (1976)]. His model accurately predicts the induced rolling moment due to canard deflection at small (± about 1°) angles of attack and side-slip. The limitation to these low angles is primarily due to the neglect of the tail surfaces when computing the trajectory of vortices trailing from the canards. The work of Shinar on finned bodies-of-revolution at low angles and the work of Rom and Portnoy on low-aspect-ratio surfaces at high angles presage the nucleation of a center of expertise in missile and high-incidence aerodynamics at the TECHNION.

In the areas of combustion and reacting flows, the hiatus due to a shortage of personnel, referred to by D.F. Dyer (ESN 27-6:149), has largely been resolved by the internal recruiting of students and faculty carried out by Dr. Y. Timnat. Several programs are now underway to investigate problems that are displaced in varying degrees from practical applications. With Dr. Y. Goldman, an experimental program has recently been completed to evaluate various tunnel-burner geometries for use with industrial furnaces. (Tunnel-burners are a sort of vaporization and pre-combustion chambers that isolate the fuel injectors from the main combustion area in order to achieve more stable and complete combustion.) The results are reported in TAE Report No. 293, October 1976. With several thesis students Timnat has continued his investigations of vaporization and ignition problems associated with hybrid rocket combustors and hydrazine gas generators (the latter with Dr. D. Adler of the Mechanical Engineering Department). These works have been largely experimental and will probably diminish due to decreases in external support.

On the theoretical side, Timnat (with Dr. A. Burcat) has provided extensions to the Taylor-Sedov problem of the propagation of a disturbance generated by a point explosion. The theory incorporates the effect of a combustible medium in which combustion is induced by the advancing spherical shock. Two-phase combustible flows have been analyzed by Timnat with Dr. M. Wolfshtein, whose prowess with

computational fluid dynamics stems from his graduate work at Imperial College, London. These works are reported in *Acta Astronautica* 3, pp. 241-280 (1976) and consider unmixedness (wherein instantaneous local reactant concentrations can be reduced to zero due to turbulent fluctuations in local flow properties) and injection, vaporization, and mixing problems in hybrid combustion.

The group headed by Timnat appears to be developing a strong capability in the numerical treatment of combustion processes, and this will no doubt support his ultimate aim to develop a comprehensive computer code to predict combustion-chamber performances and provide design criteria. The present problem, according to Timnat, is a dearth of experimental data to corroborate the assumptions made in the theoretical developments. Much of these data will be forthcoming from the well-equipped aerothermochemistry labs at the TECHNION.

In addition to the work mentioned above, Wolfshtein has developed a capability in the Department for the modeling of turbulence and for the calculation of three-dimensional turbulent boundary layers. He is now applying this capability to a novel, if somewhat optimistic, method for the reduction of drag. Wolfshtein believes that there is sufficient understanding of turbulent bursts to undertake their numerical prediction. He refers to these as "drag carrying" events, and his ultimate aim is to devise methods in which their rate of generation might be suppressed. The approach, as I understand it, would be to model numerically a two-dimensional laminar patch of flow immersed in an external three-dimensional turbulent boundary layer. An investigation of the stability of this patch, in the presence of the adverse pressure fluctuations in the surrounding flow (about which some assumptions would have to be made), would lead to a capability to predict the spatial and temporal distribution of the bursts. Once this information is available, Wolfshtein has a number of ideas about eliminating the bursts. These largely involve the use of ribbed or wavy walls, or compliant surfaces. He is most enthusiastic about the potentialities, citing annual savings of $500-million for US airlines, but right now he would like to obtain a small advance on this to finance further investigations.

With about 1050 students (900 undergraduates) and 50 faculty, the Mechanical Engineering Department is one of the largest at the TECHNION. One of the upper-division options is power engineering, and here Dr. D. Adler conducts research that is largely aimed at determining the performance of rotating machinery. He has recently completed a general computer code employing the finite-element method to predict the steady, inviscid, subsonic flow within a class of machinery that is geometrically unrestricted. This program is to be refined by the addition of viscous corrections, using integral methods, and will ultimately be extended to include transonic and supersonic flows. On a more global scale, Adler is developing codes for the simulation of the dynamic behavior of power systems. Although Adler would like to have large-scale turbomachinery at hand to test his models, the lack of such equipment has encouraged him to establish healthy working relationships with foreign laboratories. Much of the data that he uses is furnished by the Von Karman Institute (in Belgium), the DFVLR (in Germany), and the General Electric Company.

In the Department of Civil Engineering, Professor M. Poreh has long contributed to the understanding of the behavior of turbulent flows that are treated with drag-reducing additives. His approach to the analysis of such flows (described at the ONR-sponsored Symposium on Structure of Turbulence and Drag Reduction, in Washington, DC, June 1976) is best summarized in his admonition to "think laminar", a view that is brought about by his observation that the effect of drag-reducing additives is to decrease the value of eddy viscosity near the wall. Poreh, who has recently returned from sabbatical leave at Colorado State Univ., is now mainly concerned with the heat-transfer aspects of such flows and has authored a chapter on the subject in the most recent edition (12th) of *Advances in Heat Transfer* (Academic Press). In the practical vein, he sees the usefulness of polymer additives as largely restricted to short-term applications such as injection into an oil delivery line upon the failure of a pump or for briefly reducing the drag of watercraft.

Poreh is also exploring the possibilities of a novel scheme for the control of the diffusion of gaseous emissions. He has shown that the direction and rate of spread of gaseous species in a turbulent flow can be markedly altered if their emission into the surroundings is controlled to be in phase with selected components of the turbulent velocity fluctuations in the surrounding flow. In vertical injection into a horizontal crossflow, for instance, synchronization with the downward velocity component of the crossflow will result in a significantly lower plume. There are some obvious applications to the design of industrial and military exhaust systems.

These remarks have covered only a few of the highlights of my visit to the TECHNION, and the visit itself was too brief to provide a complete coverage of activities in fluid mechanics. There is definitely a lot going on, and just about every area of contemporary fluid-mechanics research is receiving some form of attention. The TECHNION is an intriguing institution: where students and staff are subject to short-notice call for national military service, where faculty serve guard duty to examine purses and briefcases for bombs, and where there is a distant vision of a bright future but a pragmatic acceptance of the uncertainties associated with the near term. American involvement in the institution is exemplified by the Mechanical Engineering Power Laboratory where 14 of the 18 researchers possess doctorates from US universities. This involvement and many other things are changing, and the adjustment to steady-state will probably prove to be as difficult as was the enormous surge of the last decade.

Another but related worry, discussed by Rom and others whom I met, is the now-familiar priority pendulum whose oscillations between research for discovery and research for industry seem so hard to stop. Much of the engineering research at the TECHNION and elsewhere in Israel has far exceeded the level at which it can be assimilated by the nation's industry and, since the export market for research is bearish at best, this is a crucial issue.

The "years of great plenty" in Israeli academia have come to an end even more abruptly than they have in the US. The challenge now is to avoid an analogy with Joseph's interpretation of Pharaoh's dream, that "...then shall arise after them seven years of famine; and the plenty shall be forgotten..." (Robert H. Nunn)

RADIO RESEARCH AT HELSINKI UNIVERSITY OF TECHNOLOGY

Finland (*Suomi* in Finnish), an independent country since 1917, has a total population of 4.7 million. In recent years its facilities for higher education have grown at a very rapid rate. In 1956, universities existed only in two cities, Helsinki and Turku; now there are 18 universities in 9 cities around the country. Electrical engineering was first established as a separate department at the Helsinki University of Technology (HTK) in 1941. Currently EE programs are also offered at the universities in Oulu and Tampere, but the department at HTK is by far the most important.

HTK has ten academic departments covering the usual engineering divisions, architecture, forest products, technical physics and general sciences. The total undergraduate and graduate enrollments are around 5500 and 800 respectively, of which approximately 1000 undergraduates and 230 graduates major in electrical engineering. The first degree, Diploma Engineer (Dipl. Eng.) which requires a thesis, normally takes four and one-half years to complete. Graduates with the first degree can continue their studies leading to a Licenciate of Technology (Lic. Tech.), or further to a Doctor of Technology (Dr. Tech.) degree.

In 1969 the Electrical Engineering Department moved into a very large building (total floor area: 22,600 m^2 at HTK's new campus in Otaniemi, 10 km west of Helsinki. Teaching and research in the Department are divided into four main Groups: Electromagnetism, Communication Engineering, Automation and Power Engineering. The Radio Laboratory, headed by Professor Martti Tiuri, is a unit in the Electromagnetism Group and it is staffed by approximately 50 people. Recently Tiuri invited me to visit his laboratories on campus as well as the new Radio Observatory at Metsähovi, 30 km away, which is also operated by the Radio Laboratory. I had long

discussions with Tiuri, Associate Professors V. Porra and I.V. Lindell and Dipl. Eng. S. Tallqvist. The following is a summary of the research activities at HTK's Radio Laboratory.

Research work is now going on in five areas: electromagnetic theory, waves and antennas; microwave theory and applications; radio science and radio astronomy; circuit theory and computer-aided design; and laser applications. In the electromagnetic theory, waves and antennas area, a major effort is being devoted to the design and applications of chain and grid antennas. The chain antenna is a novel traveling-wave antenna disclosed in the US by Tiuri *et al.* at the 1974 IEEE International Symposium on Antennas and Propagation in Atlanta, Georgia. It consists of a ground plane and a chain-shaped conductor with rectangular loops, along which a TEM (transverse-electromagnetic) wave propagates. Several chain antennas can be connected in parallel to form a grid antenna which gives a linearly polarized frequency-scannable pencil beam. A particular advantage of a grid antenna is that only one feedpoint is needed for hundreds of radiating elements. Tiuri's group has designed a grid-antenna array for VHF applications which yielded a 30-dB gain at 223 MHz with a 3-dB beamwidth of 9.5 degree. Recently they also developed a printed-circuit grid antenna for a radio link at 1.8 GHz. Plans were underway to design radiometer antennas for the remote sensing of sea ice.

On the theoretical side, Lindell has published a number of significant articles on vector impedance functions and on dyadic formulation of wave normal and ray surfaces. I was especially pleased to meet him as he has extended some work I did on the wave behavior in bianisotropic media.

The microwave work at the Radio Laboratory includes studies on the use of tunnel and point-contact Josephson junctions in low-noise microwave mixers and amplifiers and the performance evaluation of transfered-electron devices in the 20-40 GHz range. Several projects on the industrial applications of microwave are of interest. One project involves the development of a microwave instrument for the non-destructive testing of the homogeneity of supercalendar rollers used in paper mills. A flat coaxial transmission line a half-wavelength long at 1 GHz is used as the sensor and the variations of its resonant frequency as it moves along the surface of the roller are recorded by an electronic system. A sensitivity of better than 0.1% has been achieved in measuring small changes in the dielectric constant, and a patent on this system has been applied for.

A related project is the use of a dual-mode microwave cavity for determining the fiber orientation in paper. Normally the two cavity modes have the same resonant frequency with mutually perpendicular electric fields. When paper is inserted in the cavity, the resonant frequencies will differ because fiber orientation in the paper causes a dielectric anisotropy. This difference is measured and calibrated to determine fiber orientation. Resonant frequencies in the neighborhood of 3.4 GHz are used; but moisture and thickness variations affect the choice of an optimum bandwidth.

In microwave remote-sensing, attention is directed primarily toward the use of radiometers for measuring the characteristics of sea ice. The noise temperature of sea ice is a function of its thickness and dielectric properties which, in turn, depend on temperature, salinity and frequency. A computer program for calculating the noise temperature of sea ice has been developed which is being improved to take into account the effect of multiple reflections. Experimental work is being done by specially designed 610-MHz and 4.75-MHz radiometers. It is found that the difference in the noise-temperature distributions over ice ridges at these two frequencies can be used to locate such ridges.

HTK's Radio Laboratory is one of the very few academic units in the world that can boast the possession of a large precision radio telescope. The telescope antenna at Metsähovi is a Cassegrain system made by a US firm. The diameter of the main reflector is 13.7 m with an rms surface accuracy of 0.3 mm at reference conditions (60-degree elevation). The measured pointing repeatibility is about 3 arc sec. A radome with a 0.5-dB attenuation and a 90% reflection coefficient for solar heat encloses the reflector system and the pedestal. The total weight is approximately 35 tons. The reflector can be controlled

either manually or by a Hewlett-Packard 2100A minicomputer. It is an impressive sys[illegible]

Laboratory personnel have designed and constructed two radiometers to operate at 11.6 GHz and 80 GHz respectively, and are in the process of developing a spectral-line receiver to operate at frequencies above 10 GHz. Initial projects in the area of radio science included attenuation measurements of the radiation from Cassiopeia A at 11.4 GHz under different weather conditions. Propagation experiments to investigate the usefulness of frequencies above 10 GHz for satellite links are also being conducted.

The group working in the area of circuit theory and computer-aided design consists of about eight people under the general direction of Associate Professor Porra. Porra is a young, dynamic and friendly person. At the time of my visit, he was the Acting Professor as Tiuri was officially on leave with the Finnish Academy (but remained on campus). Considerable effort is devoted to the analysis and synthesis of transmission-line circuits. Two problems deserving special mention are the analysis of lossless transmission-line networks using the state-variable method and the development of modal equivalent circuits for generalized interdigital filters. Transmission lines cannot be handled directly by the state-variable method because the state of transmission lines is a function of both time and space. However, it was found that the set of partial differential equations for lossless transmission lines could be replaced by a differential equation set and a difference equation set. These new equations could then be solved in the time domain by normal procedures. The modal equivalent circuits for interdigital filters were derived on the basis of orthogonal mode expansions of the voltages and currents on a multiconductor transmission-line section. This is a useful technique and can be extended to analyze lossy and inhomogeneous structures. The work on computer-aided design at the Radio Laboratory deals mostly with symbolic-network analysis, transfer-function optimization and multilayer strip-line circuits.

In the laser applications area, an on-going project is the development of a satellite rangefinder. A Q-switched ruby laser generating 20-nsec 1-J pulses, a stable 2-kV power supply, and an integrating receiver for the detection of laser returns have been constructed and tested. The laser station is to be installed at the Metsähovi Radio Observatory. Also under development are several dye and nitrogen lasers to be used for remote-sensing experiments.

The overall impression of my visit to HTK's Radio Laboratory is that they have a vigorous group of competent people and good experimental facilities. Given these two ingredients, the Laboratory will continue to do good work in the future. When the precision radio telescope is in full operation, significant results on wave propagation and radio astronomy are to be expected. (David K. Cheng)

GENERAL

ZIP CODES IN THE UK

In mid-1977 a field test will commence for the postal code optical-character-recognition (OCR) system developed at the Post Office Research Centre (PORC), Martlesham Heath (near Ipswich), Suffolk. The prototype will be put to work at the PORC reading the postal codes ("postcodes") on letters brought over from the Ipswich post office. The reading of these codes has so far been done entirely by human beings who, in the more advanced postal sorting offices, operate keyboards that control the placing of phosphorescent ink dots on the envelopes.

Automatic sorters actuated by the glow from these dots just after exposure to light have already been put into service in a number of post offices around the UK. Their wider implementation is proceeding now that the Union of Post Office Workers, whose members have life tenure, is satisfied as to the rewards for cooperation. The OCR system is intended to automate the reading of the postcode and the printing of the machine-readable phosphorescent code. Eventually there are to be 80 mechanized letter offices replacing the present 1800 manual offices and giving further economies through the simplification of the circulation of mail between offices.

In order to simplify the sorting of the mail, the Post Office initiated the use of postal codes in greater London in the middle of the nineteenth century. Before that, addresses in London had to include the names of the villages whose agglomeration had formed the metropolis in order to distinguish streets with identical names. The first postal codes--one or two letters, such as WC (for West Central), E, or NW--were introduced in 1860. In 1920 one or two digits were inserted after the letter(s) in order to resolve the many ambiguities that still resulted from dropping the village names, and eventually the other large cities of Britain, too, divided their metropolitan areas up into postal districts by means of one-or-two-digit numbers just as in the US.

It should be noted, however, that even this subdivision does not permit the omission of qualifiers such as "Avenue", "Close", "Crescent", "Gardens", "Lane", "Mews", etc., as there are often many addresses in the same district that are distinguished only by these words or, in some cases, by their absence, as in "Picadilly" and the "Strand", which are not to be confused with "Picadilly Circus" and "Strand Lane".

To permit the automatic sorting of mail, the British Post Office around 1970 began to introduce further subdivision of the areas of central London, whose codes involve only one digit, distinguishing the resulting oddly-shaped regions by means of a letter annexed to the one or two letters and the digit already in use. Similar codes (without any final letter) were simultaneously devised for all areas of Britain, forming the "outward codes" (e.g., B15, MK42, WC2R, N4, and NW1), which are equivalent to the 5-digit US zip codes. Although the original aim had been to make these all two letters plus one or two digits, the political requirement to preserve the old London postal codes in recognizable form led to this compromise.

At the same time the "inward codes" were added, consisting of one digit and 2 letters, to complete the present "postcodes" with a total of 5 to 7 characters, such as NW1 5TH, which in fact designates Edison House, the building at 223 Old Marylebone Road in London, where ONR/London is located along with the US Air Force's European Office of Aerospace Research and Development and the US Army Research and Standardization Group (Europe). To allow for expansion and to permit error detection, not all of the possible combinations are used, and the allocations are subject to change as new towns or large businesses arise or old ones die or move.

At present there are altogether 120 "code letter areas" in the UK distinguished by the one or two letters at the beginning of the outward code, and there are 2700 outward-code districts. The digit that begins the inward code further subdivides the country into 8900 "sectors", each containing an average of 170 postcodes. Although the format would allow a much larger number, only 1,500,000 postcodes are actually utilized at present, and each one covers from 1 to 70 addresses--15 on the average.

To date, the Post Office has only partially utilized the full postcode, sorting mail into combinations of postcodes differing in the final 2 letters of the inward code, which may all be carried by the same mailman. The mailman must in any case do the final sorting.

The optical-character-recognition system to be field tested this year is the second OCR system to be built by the UK Post Office; the first, called "Caltrop", was developed by Dr. A.W.M. Coombs at the Post Office's Dollis Hill Research Station in London several years ago--before the PORC had been built--but the Caltrop failed to meet the requirement of a 1% maximum error rate for typewritten postcodes of assorted quality.

The Caltrop system (named after an ancient iron implement of war having 4 points that might extend from the center of a cube to 4 non-adjacent vertices, one of which would become imbedded in the hoof of any horse stepping on it) was based on the notion that noise would be the principal problem in character identification, causing some features of a character to disappear or to appear erroneously, and thus moving the point representing it in feature space to a neighboring vertex of a hypercube. (Feature space is a lower-dimensional projection of the observation space, in which only relevant aspects are retained.) It involved the selection and weighting of a set of features of observed characters in such a way that the 34

possibilities (A-Z and 2-9) became equidistant vertices of a hypercube. These features were extracted by means of a flying-spot (cathode-ray tube) scanner.

In the present OCR system, constructed between March 1976 and January 1977, this approach is considerably modified by using a charge-coupled array to store the observed pattern as a 512 x 64 matrix with 16 gray levels available for each element. The postcode is first located, then segmented into characters, and each character is normalized onto a 16 x 24 array by interpolation from the pattern originally stored in the 512 x 64 array. A threshold level of gray is selected that, as the dividing line between black and white, will make each character one-third black, and up to 40 features are evaluated for the resulting 384-bit array, these features being the most significant eigenvectors of the covariance matrices associated with the 34 different characters. Each 384 x 384 covariance matrix is formed from the 384-bit vectors representing one character in all of the fonts that are to be recognized.

Each of the 34 possibilities receives a score that takes into account the statistical dependence between features, and the character with the highest score is selected. Errors are due mainly to incorrect segmentation. This OCR system functions satisfactorily on hand-printed symbols as long as well-separated block capitals are used, but the present plans envisage its use only for metered mail, which will have printed or typewritten addresses and will arrive at the post office with all letters already facing the same way.

The OCR system uses Schottky transistor-transistor logic with a 26-MHz clock, recognizing the 7 characters in 70 ms as the mail moves at a constant speed (8 pieces per second) past a set of 3 cameras looking at different heights for the postcode. It should be the last thing (if not, as the Post Office would prefer, the only thing) on the lowest line of print.

The system invisibly inks and checks two 12-bit words (representing the outward and inward codes) beneath the address before sorting into local, non-local, and problem bins. Once the letters in the last bin have been given their proper phosphor ink dots, all can be fed to automatic sorters handling 16,000 items per hour. The automatic recognition of each character involves 800 x 34 multiplications in 12-bit arithmetic, requiring some parallel processing, but the electronics occupies only 2 racks of printed-circuit boards, power supplies, etc.

This OCR work is done under the direction of Frank A. Milne of the PORC's Postal Engineering Research Division, which is headed by Stanley G. Young. They report that many British businesses are finding the postcodes useful for designating sales districts, for routing delivery vehicles, for statistical surveys, etc., both because the Post Office can provide information about the number of addresses within each area, sector, and code, and because the postcode provides a uniform standard that permits easy cooperation between different organizations.

The Post Office has a magnetic-tape file of all addresses in the UK in postcode order, which is updated quarterly. It includes 4 additional digits, called the "premcode" to distinguish every address. Copies or address-label printouts of this tape or portions of it--such as every n^{th} address in any area for $1 \leq n \leq 99$--can be bought by businesses for use in their sales campaigns, but these addresses include the householder's name only in rare instances. There is no systematic relationship between the last letters of the postcode and the location to which they refer, but the Post Office offers street-by-street listings of postcodes, etc., and maps on various scales are available.

The postcode represents a big step toward the faster, more efficient handling of mail, and Canada has already adopted a similar scheme, employing 6 characters alternating between letters and digits. Although this alternation makes for an unforeseen amount of motion of the typewriter's shift key, the use of such detailed postal codes appears to offer many advantages. (Nelson M. Blachman)

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SYMPOSIA AD NAUSEA

"What did you think of the Conference?" The answer to this question often depends upon who asks it as well as who is asked. For instance, a generally favorable response can be expected from conference organizers and invited dignitaries. Likewise, those who provide the funds for conference attendance will probably elicit a favorable response from their beneficiaries. The ordinary conference delegate, however, is much less likely to wax enthusiastic when he asks the question of himself. And how many of us will admit that we actually like conferences?

Every year there are thousands of gatherings throughout the world in which common interests, from beekeeping to positron annihilation, draw investigators together. Many of these gatherings are highly productive (they certainly provide a lot of the information found in these pages), but there is a wide range of quality. It's a "win some, lose some" sort of thing, and somehow I think the batting average could be better. For those who contemplate throwing a technical get-together, the following checklist is offered. If some of the points seem obvious, I can assure you that I have attended conferences at which most of them have been overlooked. And the list is not complete. For instance, there is a presumption that the meeting is needed.

1. Select limited topical areas, e.g. "Wind Power"--not "Alternate Energy Sources". This tends to create a delegation which is limited in size and truly interested in the meeting subject.

2. Plan ahead. Get announcements out well in advance. These should include a provisional program (with titles and authors), a clear description of the venue, accommodations and special events, and a breakdown of fees that does not require interpretation by a CPA.

3. Require fully prepared papers from the authors, and distribute them to the registrants at least two weeks prior to the meeting.

4. Plan the program content to allow for a good balance between theory and practice (unless, of course, the theme specifically calls for one or the other).

5. Don't have too many papers--perhaps 2 or 3 per session with 3 or 4 sessions per day. Schedule breaks between each session.

6. Allow ample time for discussion--a minimum of half the time alloted to presentations. As a stimulus for discussion, it often helps to use an "old curmudgeon" if you can find one. Try to keep the discussion oriented to the theme and content of the presented material. Don't allow this to be nothing more than a relief-valve for rejected authors.

7. Select keynote speakers and session chairmen who are familiar with broad aspects of the technical subject, such as national programs and priorities, historical developments and goals for the future.

8. Have the meeting in an attractive environment that is convenient to public transportation and accommodations. Universities often offer ideal facilities.

9. Have a limited number of high-quality "special-events" (tours, banquets, etc.). Include their cost in the registration fee. Treat these events as part of the program. Do not have a myriad of alternatives that confuse and divide the delegation.

10. Have a few professionals out front at the Conference. A "professional" is defined here as someone who is intimately familiar with the planned program and events, tries to learn the delegates' names and can exhibit an air of being in control--even if all else seems to be in utter disarray. (This definition generally excludes scientists, engineers and educators.) (Robert H. Nunn)

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MATERIALS SCIENCES

STRENGTH AND DEFORMATION OF METALS AND ALLOYS

The examination of this problem area continues its march around the globe. Following successful meetings in Japan, United States and England over the past nine years, the Fourth International Conference on the Strength of Metals and Alloys was held at Nancy, France, from 29 August to 4 September 1976. More than 400 people attended from at least 22 countries, including 29 from the US, an impressive contingent. As is now the tradition for this international meeting, the local organizing committee did an excellent job, and the usual gripes about service and facilities were pleasantly absent.

The success of the Conference also produced problems. More than 230 papers were scheduled. Since only one of the two parallel sessions provided simultaneous translation (French, English, German), the all-English session (often a surprise to the non-English speaking speaker) produced a mélange of presentations, some quite difficult to follow. To accommodate the large number of papers, several of the sessions used a rapporteur to summarize each of the papers, following this by a brief statement by each of the speakers. One of the four-hour sessions presented 32 papers in this manner. The rapporteurs were very conscientious and gave excellent overviews, but the sheer mass of information was, on occasion, discouragingly difficult to assimilate. Notwithstanding these problems, the Conference went quite smoothly. The simultaneous translations were excellent, most of the papers were of high quality, and ample time (amazingly enough) was given for formal and often lively discussion. The discussions were all the more stimulating as a result of technical differences in approach and attitude among scientists from different countries. The friendly and often vigorous exchange was a highlight of the Conference.

The Conference sections were organized around eight keynote papers presented by an international group of academic and industrial scientists. These served to provide an overview and focus to the remainder of each session, and were usually quite successful. The two parallel themes of the Conference, a review of recent progress in the understanding of strengthening mechanisms, and the application of these concepts to alloy design, were equally stressed, providing excellent balance.

Professor R. Pelloux (MIT) gave an excellent talk on the optimization of microstructure for fatigue resistant engineering alloys, in a variety of test environments. Using specific examples, such as high strength 7000 series aluminum alloys (containing Zn and Mg as major solutes), he demonstrated that metallurgical control of the precipitate microstructure and distribution could lead to improved fatigue resistance in both dry and moist air. The latter environment can be particularly severe since corrosion can accelerate the fatigue process. Although much is yet to be learned about the specific process controlling the stress and stress intensity dependence on fatigue crack growth rate, there is now real promise that these factors can be integrated into existing and developing alloy design procedures. As Pelloux pointed out, this is already largely the situation in aircraft, turbine engines and other critical applications.

An intriguing presentation was provided by Dr. A.R.C. Westwood (Martin Marietta, Baltimore) on environment- and surface-sensitive mechanical behavior. He convincingly demonstrated that an understanding of rather academic topics such as liquid-metal embrittlement (catastrophic fracture of solid metals by specific liquid metals) and the Rehbinder effect (softening of the surface of a material by specific and usually organic agents) can be exploited to improve such commercial processes as machining, rock drilling and lubrication. The Russians are already using liquid metal eutectic alloys to enhance machining and drilling rates. In the US an improved electro-machining procedure has been developed. This takes advantage of the discovery that an imposed potential between the electrode and the work pieces can accelerate either brittle fracture or enhanced plasticity. This tendency is controlled by the potential at which the surface charge on an electrode vanishes, which in turn should affect the bond strength of surface atoms. The

understanding of the physics of the process is still incomplete, and as Westwood pointed out, successful commercial exploitation of such processes may be years away. Nevertheless, this is an exciting area of development which should give added encouragement to the many scientists who believe that fundamental studies can lead to solutions of real engineering problems. Often the missing ingredient is identification of critical problem areas. As the above example illustrates, these can often be provided in the multidisciplinary atmosphere of international conferences.

Other keynote talks included those by Dr. D. McLean (National Physical Laboratory, UK) and Dr. J. Jonas (McGill Univ.). McLean summarized some of the ways the grain size of an alloy can influence plastic flow, particularly at high temperature. To suppress high temperature creep, a serious problem for reactor components, gas turbine engines, etc., a stable grain structure must be maintained. This requires suppression of grain boundary sliding and grain growth. To achieve this, the complementary role of dislocation motion, which is often complex, must be characterized, particularly as how it controls grain boundary sliding. McLean outlined how such an understanding may be developed by examining the strain, strain-rate, and temperature dependence of high temperature flow. He demonstrated that this approach can successfully rationalize the deformation behavior of the complex multi-phase alloys developed for high temperature applications.

Jonas illustrated how the important process of hot working is intimately related to the concomitant processes of dynamic recovery and dynamic recrystallization. Since the latter returns the material to an essentially non-deformed condition, and since it is usually in competition with the former which does not, the relative control of these phenomena is critcal. This necessitates an understanding of high temperature deformation, in a manner similar to that described by McLean. Strain, strain-rate and temperature studies led to functional relationships which could be used to identify the ideal test parameters for a given alloy in order to optimize the hot working process. Jonas pointed out that while some progress has been made towards this end, considerable additional work is needed, since different alloy systems can behave quite differently even under the same working conditions.

A pre-eminent topic area in many of the submitted papers was the application of thermomechanical treatments to forming and to the optimization of strength and toughness of engineering alloys. A number of speakers showed that the proper combination of temperature and working could produce an optimum microstructure. For example, in eutectoid steels, strength and toughness are controlled by different microstructural features, and thus both can be optimized for the production of improved rail steel (Bernstein *et al.*, Carnegie-Mellon Univ., US). Microduplex steels, containing a mixture of martensite and ferrite, have good fatigue resistance and fracture toughness at room temperature and below, and show promise for cryogenic applications in which toughness is usually the critical design parameter (Stratmann and Hornberger, Institute für Werstoffe, Bochum, Germany). Manganese steels are being developed as a substitute for the more expensive alloy steels containing nickel and chromium. By thermomechanical control of the decomposition and martensitic reactions through controlled rolling, these steels can be produced with high strength and good impact properties and can therefore compete with the more expensive normal alloy steel grades (Lariot, Schmitt and Gantois, Laboratoire de Génie Métallurgique, Nancy, France).

These thermomechanical techniques were not restricted to steels. Precipitate microstructure and relative distribution between the lattice and the grain boundary were exploited to improve fatigue crack growth in austenitic stainless steels, high strength aluminum alloys, and a zinc-aluminum eutectoid alloy, as reported by German and British investigators. Inert dispersoids improved the creep behavior of numerous alloy systems (Evans and Knowles, Berkeley Nuclear Lab., UK). Other alloys systems shown to be amenable to improvement of properties by thermomechanical processing included alpha and beta titanium alloys, beryllium alloys, zirconium alloys and others.

The wide variety of structural alloys considered at the Conference relate to numerous critical application

areas: Ferritic steels are important for structural components needing high strength and toughness, often at cryogenic temperatures. Austenitic stainless steels are important where corrosive influence could be present. Since some of these are high temperature applications, creep resistance is important. Titanium alloys are used for aircraft and engine applications, and proper processing for good combinations of strength and toughness is required. Nickel-base alloys used in high-temperature gas turbines must have high-temperature strength and good fatigue, creep, and oxidation resistance. Zirconium alloys find wide use in nuclear systems and must be resistant to a wide variety of embrittlement phenomena.

This is by no means a complete list, and the applications and properties listed above are not exclusive to a given material. They serve to illustrate the breadth of this Conference. One rewarding conclusion is that many of the control procedures discussed, such as microduplex structure controlled rolling, and optimization of the precipitation process, have broad application across specific alloy systems. In this way the possibility of development of broadly applicable design guidelines has been strengthened.

As an example of French efficiency, the Proceedings (minus some of the keynote talks) were sent to the participants prior to the Conference. This allowed for careful study of specific papers of interest, and the quality of many of the prepared discussions demonstrated how valuable this was. It even made carrying the 1000-page, two-volume set, around Europe bearable (almost). The Proceedings can be obtained by contacting the Laboratoire de Physique du Solide - E.N.S.M.I.M.I.N.P.L.-Parc de Saurupt, 54042-Nancy, France. Rumor has it that the next meeting will be in Germany, probably in 1979.
(I.M. Bernstein, Dept. Metallurgy and Materials Science, Carnegie-Mellon Univ., Pittsburgh, PA)

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THE ELECTRON MICROSCOPE LOOKS AT SURFACES

With a full commitment by a set of dedicated young scientists, Britain carved out a position of pre-eminence, some 20 years ago, in transmission electron microscopy (TEM) research on materials, particularly metals. The experimental achievements are numerous, and the theoretical bases for TEM (e.g., the dynamical theory vs. the kinematic theory) bear a distinct British imprint. However, TEM has traditionally been most concerned with investigations of the bulk of materials--at least, insofar as the inevitable thin foil would permit. Frequently the surfaces of the samples being viewed were regarded as unfortunate, but unavoidable, "artifacts". One attraction of the high energy (e.g., 1-MeV) TEMs that have appeared over the last decade is the opportunity to dig deeper into the bulk and away from the surfaces.

The contemporary swing in emphasis to surface phenomena (e.g., catalysis) has not escaped British TEM researchers, however. Accordingly, the one-day meeting of the Institute of Physics held at Imperial College on 10 December 1976 was addressed more to the future than today. The meeting, entitled "The Observation of Surfaces and Surface Reactions by TEM and SEM" (scanning electron microscopy), provided an overview of British activity in this relatively new subfield. All speakers but one were from the UK; I counted 7 foreign scientists in a gathering of over 50. M.W. Stobbs (Cambridge) chaired the meeting.

A. Howie (Oxford) opened the meeting with one of the four invited presentations. He immediately acknowledged that TEM has not been established as a primary tool for surface study, in competition with other techniques such as LEED (low-energy electron diffraction), RHEED (reflection high-energy electron diffraction), THEED (transmission high-energy electron diffraction), Auger spectroscopy, ESCA (electron spectroscopy for chemical analysis), etc. Some of the disadvantages of TEM relative to these other methods arise from the high energy of the electrons in use in TEM, reducing its sensitivity to the surface phenomena. But TEM does have some advantages, too. TEM can provide

a real-space view of the surface, and it is almost axiomatic that direct viewing of an object or phenomenon is highly instructive; later speakers gave ample demonstration of this. In addition, TEM studies can be conducted at relatively high pressure (i.e., 1 atm), albeit with special apparatus and methodology.

Howie showed slides of patchy oxide coatings on Ni, using direct "weak beam" microscopy with fringe observation, looking both in light- and dark-field transmission. He then addressed the obvious next question: Can TEM observe the surface structure at lower atomic coverage? This is an area in which LEED has been used very profitably. The answer, according to Howie, seems to be a qualified yes, but poorly at present, at least. Some extra diffraction spots, for example, can be found due to surface lattice structure, but reconstruction is difficult.

Finally, Howie pinpointed the cause of difficulties in the application of SEM to surface studies--the relatively low energy loss of beam electrons to plasmons. LEED and Auger spectroscopy use electrons with energies of about 100 eV. The electron energy of 10^4 - 10^5 eV in electron microscopy gives rise to plasma losses in the samples that are reduced by 10^2, typically. As a result, background signal is higher in the electron microscope. The obvious way to minimize the plasmon problem is to use ultra-thin samples; the use of secondary electrons is another method. Neither solution is simple.

D. Chernes (Univ. Sussex) gave an application of the TEM which is unconventional, if limited. Chernes, using the 1-MeV TEM at Harwell, bombarded Au along a <111> direction and measured the yield of atoms sputtered off the surface in transmission (i.e., off the surface opposite the electron beam incidence). Both total yield and angular distribution collected on a monitor foil are measured. The strength of the technique comes from the following considerations. The maximum energy that a 1-MeV-electron can transfer to a gold atom is less than the (approximately) 22 eV needed to displace an atom in the bulk--i.e., to cause radiation damage. But sputtering requires only about 5 eV, and focusing of energy, particularly down <110> directions, effectively amplifies sputtering in that the electron-atom energy transfer may occur well below the surface with efficient transfer of energy to the surface. The directionality of focusing is very graphic. Below 600 keV, the angular sputtering distribution is quite isotropic; above 600 keV, focusing causes a highly anisotropic pattern with most of the sputtered atoms accumulated into three <110> spots (in the geometry of the experiment). In addition, Chernes showed the development of pits on the surface during irradiation, aided by the coalescence of surface vacancies left by sputtered atoms. Breaks in the pit pattern appear to occur near surface steps, apparently verified by bright field TEM.

In a short contribution, J.W. Steeds (Univ. Bristol) showed that effects of twins in a high-temperature form of Ta_2O_5 causes three shades of grey in bright-field contrast, due to surface offsets and subsequent beam optics in the samples. Two shades of grey are common; three are unusual. G. Lehmpfuhl (Fritz-Haber-Institut, Berlin) discussed the use of a $(\bar{2},0,0)$ beam to excite a (10,0,0) diffraction to resolve steps down to about 2 Å.

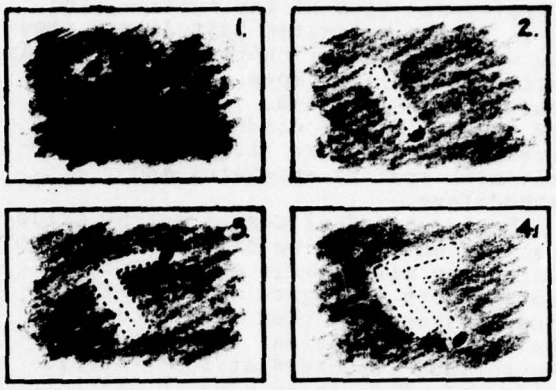
In the second invited paper, J. Venables (Univ. Sussex) discussed two topics, the first being the observation of rare gas (Xe) adhesion on graphite at about 80 K. Venables stated that he had previously seen Xe islands. The technique was modified, eliminating the Xe atmospheric chamber. A graphite surface, well-cleaned by heating, is bombarded by a Xe beam. With this attention to cleanliness, Venables now sees continuous Xe films which are monolayers, as verified by Auger spectroscopy. The implication concerning cleanliness for all surface studies is clear, although not original.

Venables then described the new surface-study apparatus being assembled at Sussex. The philosophy of this equipment is to bring all the surface-study tools to bear simultaneously; a "Don't try to beat them--join them" philosophy. Central to this equipment is the use of an ultra-high vacuum field-emission scanning microscope. The configuration of the specimen stage is modified so that the sample is removed from its conventional position where, in an effort to achieve maximum resolution, it is normally surrounded by microscope optics (i.e., lenses). In the modification,

the sample is exposed and, therefore, available for examination with a variety of other techniques: RHEED-THEED, Auger spectroscopy, mass spectroscopy, electron back-scattering, secondary electron detection, etc. The column section near the sample position becomes a stainless steel "porcupine" with its multi-port geometry, an arrangement that increasingly typifies surface research. Venables expects to achieve a 25 Å resolution. The equipment is capable of giving either an Auger energy-scan at fixed sample position or a position-scan at fixed energy.

Finally Venables discussed the problem of accuracy in obtaining elemental composition. He showed that taking the ratio of elemental signal output to background signal is very rewarding; signals that fluctuated widely in themselves behave more smoothly (and, presumably, realistically) after referencing to background. Needless to say, signal collection and analysis are computer-assisted, and video readouts of all signals and ratios are available.

J.A. Cairns (AERE, Harwell) in the third invited talk, made the most videographic presentation of the meeting. He presented a short but highly effective movie on the catalytic decomposition of a hydrocarbon (e.g., acetylene) to form graphite and the catalytic oxidation of graphite. In the former, the film showed catalyst particles seemingly spinning out 0.1-μm-diam fibers. Two fibers are emitted, in this case, in opposite directions, and the catalyst particles move about on the substrate during the process. The oxidation case was somewhat similar; a frantic Pd catalyst particle dashes wildly about the graphite film, eating away at the film in the process. This particle moves by fits and starts, but somehow it successfully constrains itself to areas of remaining graphite and does not seem to repeat any traverse along oxidized zones. The particle is "intelligent" enough to scan, generally, a swath next to a previously oxidized zone. An illustration of the catalyst's mad meal is given in the series of sketches here. The numbering sequence denotes the progression of time, with the consumption of graphite. (N.B. These sketches are our own fabrication; no responsibility should be placed on the investigators at AERE.)



Beyond providing a fine visual picture of the mechanism of graphite fiber formation and graphite oxidation, Cairns' film served to underline the usefulness of containing a sample in a controlled-atmosphere cell. The film of oxidation would obviously be impossible without resorting to a chamber which could contain oxygen. It should be mentioned that environmental chambers are of two generic types. The first is the full isolation chamber in which bombarding and exiting particles move through thin windows in the chambers. Advantages and disadvantages of this chamber are evident. The second chamber is not completely sealed but contains very small openings and the requisite differential pumping equipment is provided.

Cairns next turned to the use of Rutherford back-scattering (RBS) of a He^+ beam to provide rapid elemental analysis for thin films. He described a case analyzed at Harwell of a Au-Fe-Au sandwich, each layer being 300 Å thick. On admission of hot O_2, the Au films were observed to break up, and eventually the Fe covered the Au. The use of RBS is, of course, limited by access to an accelerator for He^+.

M. Shannon (Univ. Bristol) described a new ZAP-map technique, where the acronym stands for zone-axis patterns. With this technique, Shannon looked at materials with similar structure (as an example, SnO_2 and $SbVO_4$) and attempted to provide chemical and phase analysis for the materials. ZAP-map depends on the fact that a polycrystalline aggregate will present a zone-axis pattern, which

counts the frequency at which a crystallographic direction points in a particular direction in space, with respect to an incident beam line; these patterns are determined by crystallographic structure (i.e., phase). However, the contrasts in the pattern are determined by the number and distribution of electrons in the material so that an atlas of patterns from known standards should give identification of a particular material. The fly in this ointment is that the pattern details are sensitive to thickness, as well. A full ZAP-map catalog would need to show maps at varying thicknesses for each compound phase.

P. Swann (Imperial College, London) gave the last invited talk, in which he also considered environmental cells and gave several applications. In a movie, he showed the reduction of hematite (Fe_3O_4) to magnetite (Fe_2O_3) by CO; the study showed that dislocations play little or no role as nuclei for reduction. A second example did demonstrate that oxidation of a metal may depend on slip bands at the surface, due to previous deformation. Swann then presented a film on corrosion of irradiated Si at -140°C, in the presence of water. The film showed the development and growth of pits on the surface. Bubbles, centered on the pits, are then produced and grow, affording an opportunity to measure growth kinetics. The mechanism for bubble growth, offered by Swann, is that the electron-induced breaking of Si-O bonds, in the presence of water, generates the H_2 which exerts the gas bubble pressure. In the presence of water, the bubble grows indefinitely; in the presence of dry He, it "dries out" and bursts. Swann even proposed an application of corrosion, in the microscope. By choosing the corrosion medium, one can "write" in different colors on a surface.

The meeting, in summary, displayed an impressive variety of activities in surface studies using electron microscopy. For this reviewer, two items were notable. The use of environmental techniques should be a method that will become increasingly frequent. Second, the use of electron microscopy as an adjunct to other surface techniques will certainly grow. (Al Sosin)

MATHEMATICAL SCIENCES

THE NAG LIBRARY OF ALGORITHMS FOR ENGINEERING AND SCIENTIFIC COMPUTING

High quality "numerical software" is as vital to the operation of engineering and scientific computing centers as the computer itself. The Mark 5 version of the numerical software library developed by the Numerical Algorithms Group (NAG) at Oxford with the cooperation of more than one hundred of Britain's leading numerical analysts and software experts is unquestionably one of the very best scientific subroutine libraries in the world. Until recently, this library was available only to British universities and government computing centers. In a significant policy change, the NAG library, together with its outstanding documentation, is now being made available on a low-cost subscription basis to any interested organization either foreign or domestic. The purpose of this note is to provide a summary overview of NAG's operations and the most recent version of its library.

The present NAG organization is an outgrowth of an informal gathering of numerical analysts and applications users held at the University of Nottingham in May 1970. This group consisted of representatives from the Universities of Birmingham, Leeds, Manchester, Nottingham and Oxford, and the Science Research Council's (SRC) Atlas Laboratory at Chilton. The common concern of the participants was the lack of vendor-supplied numerical software for the ICL (International Computers, Ltd.) computer model 1906A which, by Government fiat, all of the represented institutions were being forced to acquire. The group, therefore, decided to embark upon a project to develop the needed software. The areas of numerical analysis to be covered by the library were agreed upon, and members of the group accepted responsibility for acquiring or developing software in specific subject areas and for writing the supporting documentation. The activity was coordinated from the University of Nottingham, and in just over a year the first version (Mark 1) of the

library was released. Mark 1 and its successors were programmed in the two most widely used languages for scientific computing--Algol 60 and ANSI FORTRAN.

Even though most computer manufacturers do provide a numerical software library for their machines, the NAG Mark 1 library was widely recognized as being superior to any general-purpose vendor-supplied software then existing, and in 1972 NAG was approached by representatives from British universities with IBM and other models of ICL computers with the request that Mark 1 be converted for use on their machines. In response, the newly constituted NAG Executive Committee appointed groups of interested university representatives to develop versions of the library for these other machine families. The resources for the implementation of the different library versions were furnished by the respective university computing centers.

NAG's early success with Mark 1 and the growing interest in and support of the project by British universities and government laboratories encouraged the group to undertake the objective of providing a numerical algorithms library in both Algol 60 and ANSI FORTRAN for use by any British university, provided only that necessary uniform standards were met. The unwavering insistence on rigid standards of software protocol has been a key factor in NAG's successful service to all library users, since it has minimized tampering with the library in order to satisfy local needs or convenience.

In 1973, the NAG Central Office staff moved from Nottingham to Oxford. At that time, the group changed its name (which had originally been Nottingham Algorithms Group), but serendipitously was able to retain the same acronym. Continued funding for the project has been provided by the Computer Board for Universities and Research Councils. However, it is hoped that by 1980 NAG will become a totally self-supporting operation. In order to facilitate this, NAG became a "non-profit-making company limited by guarantee" in March 1976. Its Director, Dr. Brian Ford, was one of the original representatives at the 1970 Nottingham meeting. The governing Council of the incorporated project is composed of five of the original founders (including Ford), two members appointed by the Computer Board, two from the University of Oxford and one from the Division of Numerical Analysis and Computing of the National Physical Laboratory. Although now incorporated, the basis for the technical work of the group remains one of non-commercial collaboration between interested members of the staffs of British universities and government laboratories.

The structure of the NAG library is based on Chapters, each of which is devoted to a specific area of numerical analysis such as solution of linear equations, solution of ordinary differential equations, location of the roots of nonlinear equations, etc. The Mark 5 version of the library which was released in the fall of 1976 has 25 Chapters and a total of more than 300 separate computer routines, i.e., an average of 12 different techniques per Chapter, so that the library user may select that method best suited for his particular problem. For instance, the Chapter on Simultaneous Linear Equations contains 17 different subroutines for solving the matrix equation $Ax = b$. The selection of the most suitable routine depends upon the structure of the matrix A (whether the matrix is full or banded, symmetric or not), the precision required and the number of different right-hand sides, b. Range of usefulness, speed and accuracy are the principal criteria used for the selection of algorithms to be included in the library.

Each Chapter is the responsibility of a Contributor whose job it is, in collaboration with other experts, to select algorithms, oversee their programming, select test problems and document the algorithms. Each Chapter also has a Validator who plays devil's advocate by independently evaluating each algorithm, checking its coding and documentation and testing it on "stringent examples". Contributors and Validators are not members of the NAG Central Office staff, but are top-ranking numerical analysts from British universities and government laboratories. Thus, the NAG staff itself does not generally get involved in the details of the numerical analysis methodology. The role of the Central Staff is primarily that of coordination, documentation, maintenance of programming standards, troubleshooting, consulting and other facets of what is termed "software engineering".

When the Validator and his collaborators are satisfied with the performance of the programmed algorithm, it is passed to Ford and his group of approximately a dozen computer software experts at the NAG Central Office for incorporation into what is called the "master library file system" (MLFS). Before doing so, the NAG staff validates the program from the point of view of programming language standards and coding practices. The MLFS contains the version of the program which has been successfully validated on whatever machine the Contributor and Validator have used. But because of different machine and compiler characteristics, the canonical version of the program recorded on the MLFS will inevitably require some modifications in order to be "transported" and run on another manufacturer's computer. The next stage in the process, therefore, is to send the MLFS to the Coordinators who are responsible for actually implementing the library on each of the machine families which NAG supports. At present, the NAG library is implemented on 13 different machine families including IBM 360/370, CDC 6600/7600, Burroughs 5700/6700, DEC System 10, Univac and various ICL models. (NAG is presently negotiating a contract to provide the numerical software library for the PRIME computer family.) Since the complete library exists in both FORTRAN and Algol 60, there turn out to be 26 different "implemented libraries". Exact copies of these are returned to the NAG Central Office where they are filed.

One of the most recent developments in the NAG project is the conversion of portions of the library to Algol 68. This work is being carried on under a research agreement with the Ministry of Defence on behalf of the Computing and Software Research Division, Royal Signals and Radar Establishment at Malvern. Currently, about 25% of the Mark 5 library has been converted and is available in Algol 68.

The annual cost of subscription to the NAG library, its more than 1900 pages of detailed documentation, and its consultation and up-dating services is £600 (approx. $1,000) for either the FORTRAN or Algol 60 versions. Both versions can be leased for £800 per year. Based upon the "$10 per line of code" rule-of-thumb commonly used to estimate the development cost of high quality, well-tested computer software, the NAG library seems quite a bargain. It is the author's belief that US organizations may greatly benefit from the enormous investment which the UK has made in the development of this truly excellent collection of high quality, thoroughly tested and readily transportable computer routines. Enquiries may be addressed to the author or to Dr. Brian Ford, The NAG Central Office, Numerical Algorithms Group, Ltd., 13 Banbury Road, Oxford OX2 6NN, England. (William J. Gordon)

MECHANICS

AGARD CONFERENCE ON FRACTURE-MECHANICS DESIGN METHODOLOGY

NATO's Advisory Group for Aerospace Research and Development (AGARD) held its 43rd meeting of the Structures and Materials Panel at the former United Services Club in London from 26 September to 1 October 1976. The discussions covered fracture-mechanics design methodology and acoustic fatigue. This report will concentrate on the former topic, which received the main emphasis.

At the opening Conference session Air Marshall Sir Herbert Durkin of the RAF presented an excellent assessment of the philosophy and problems of aircraft design, production and maintenance. According to Durkin, aircraft design methods have changed from safe-life design concepts, in which flaws and defects play no role, to damage-tolerant or fail-safe design concepts in which the effects of flaws and defects are explicitly taken into account. In both of these methods some form of inspection of the structure is required; any flaws detected are repaired in a safe-life structure, whereas a damage-tolerant structure could, in theory, be permitted to remain in service until detected flaws grow to an unacceptable level. Durkin stated that for damage-tolerant design all structures must be inspected and inspectable; i.e., in the initial design, access must be provided for inspection of all primary structures. The determination of an allowable flaw size under realistic service loading also requires definition of a realistic

loading spectrum and the accurate simulation of service loading in the laboratory in order to develop reliable failure criteria. The net result is that a definition of the nature and location of the defect, an accurate assessment of the loading spectra and an experimentally verified failure criterion are required in order to make fatigue-life predictions. These remarks led naturally to a discussion of on-board monitoring systems including the present "fatigue meters", which are counting accelerometers used to measure exceedence events which are then incorporated into a Miner's Law prediction scheme and monitoring system to detect propagating cracks and predict remaining lifetime. Additional points discussed were maintainability and reliability, as applied to design, production, service usage, educational programs and finally, a key item, feedback of operational data using a computer-based system. There was mention also of corrosion, efforts at present being directed toward correction rather than prevention, and battle-damage where the acceptable degree of damage is unknown and time is an important factor in assessment and repair of aircraft.

The meeting on Fracture-Mechanics Design Methodology was opened by Dean H. Liebowitz (George Washington Univ., Washington, DC), who presented a statement of the meeting's objectives and announced that the presentations and discussions would contribute to the design manual on "Fracture-Mechanics Design of Aircraft Structures" being prepared by AGARD. The meeting objectives were two: first, to present examples of how fracture-mechanics is or can be used in the design of aircraft structures and their components; second, to emphasize gaps in the knowledge required by the designer.

Twelve papers were presented in the meeting, all of which dealt with some aspect of fracture as it relates to aircraft design. A paper by W.G. Heath (Hawker Siddeley Aviation), L.F. Nichols (British Aircraft Corporation) and W.T. Kirkby (Royal Aircraft Establishment) was concerned with practical applications of fracture-mechanics to aircraft structural problems. A wide variety of problems was discussed ranging from cracks in stiffened wing panels to pressure-cabin design, including the effects of cracks in curved panels. The authors pointed out that present knowledge of the effect of curvature and pressure on crack growth is inadequate and that further work should be done in this area. An interesting problem was discussed which relates to crack growth under combined mechanical and thermal stress cycle. During climb to supersonic speeds, exposed surfaces are subjected to kinetic heating, but areas masked by fins or wings remain cool, while the reverse is true on reducing speed. These temperature differences give rise to thermal stresses which are superimposed on the mechanical stresses. The authors concluded, based on a limited number of tests, that a correction factor applied to the room-temperature crack-growth-rate equation can be used to predict crack growth under these conditions. The results provide convenient design guidelines, although they do not necessarily apply to the complex stress states present in some aircraft structures, and the authors listed areas requiring further attention.

Two papers, the first by W.D. Buntin (General Dynamics, Fort Worth, Texas) and the second by S.R. Murnane and T.D. Strange (Northrup Corporation, Hawthorne, California) and O.B. Davenport (Aeronautical Systems Division, Wright-Patterson AFB) discussed the effect of damage-tolerant design concepts on safe-life designed structures. It was the the initial failures in the F-111 aircraft built by General Dynamics that prompted the US Air Force to develop its damage-tolerant specifications. Buntin presented a synopsis of a "Fracture Control Program" as it was applied to the F-111 airplane. He stated that the basic difference between this plan and the current approach for safety and durability is that the F-111 work was planned and carried out after material selection and detail design were completed, rather than before. A similar picture was presented by Murnane who discussed the effect of damage-tolerant design on the F5E/F aircraft. This plane was also designed using safe-life criteria, and considerable time and effort were expended to assess the damage tolerance of critical areas. The authors of both of these papers concluded that damage-tolerant design concepts are fundamental in establishing a meaningful structural design and maintenance program

for any aircraft. An interesting question was raised in the discussion period concerning the cost of damage-tolerant vs safe-life design. This topic quickly became the subject of a lively debate focusing on acquisition vs life-cycle cost.

Two papers, the first by H. Vlieger (National Aerospace Lab, Amsterdam, The Netherlands) and the second by Professor A. Salvetti (Univ. Pisa, Italy) addressed the problems of fracture and fatigue of stiffened panels. Vlieger gave a clear presentation of the pros and cons of designing a structure for a certain crack-free life (safe-life approach) vs allowing operation of the aircraft with cracks (damage-tolerant approach). Using the latter method, he discussed the application of his computer program ARREST in determining the residual strength of cracked stiffened panels. While some degree of success is attained in these predictions, there are still major difficulties in obtaining satisfactory estimates of the crack propagation life under flight loading. An interesting point made by Vlieger is that bonded panels may be preferable to riveted panels on account of the unstable nature of the crack growth observed in riveted panels. Salvetti discussed a method for computing the fracture toughness (K) in stiffened panels with cracks, and then explained the rationale used to evaluate stringer/fastener fatigue endurance. His computer analysis included finite element techniques, analytic methods based on plane elasticity theory, and experimental data. These were combined to predict fatigue life in riveted panels where the cracks originate at or between the rivets.

Drs. S. Peyronel and R. Mantelli (Aeronautica Macchi S.p.A., Varese, Italy) presented a paper on comparative experimental and theoretical studies of fatigue crack growth. Extensive experimental data were presented relating fracture toughness to crack growth-rate for fatigue-loaded panels. Predictions of crack growth-rate were made with their computer program, FORMAN, which is based on an evaluation of Forman's equation relating crack growth-rate, stress ratio, stress-intensity-factor magnitude and range, and two empirically-determined coefficients.

Drs. R.J.H. Wanhill and C.J. Lor (National Aerospace Lab, Amsterdam, The Netherlands) presented an interesting paper on the calculation of Stress Intensity Factors (K_I, K_{II}) for corner cracking in a lug or bolted connection. Wanhill discussed various solutions of this problem and presented his finite-element analysis along with experimental data to show that most of the solutions, his included, are supported by the data. He expressed an opinion that it is cheaper to do tests with actual lugs and bushings than to do finite-element analysis because of the uncertainty of the loading, i.e., poorly-defined boundary conditions and the assumptions associated with the geometry of the flaw and the profile of the crack as it propagates. Another point, about which there was considerable discussion, concerned the effects of mixed-mode loading on the direction of crack growth. The many conflicting opinions were evidence of the general lack of firm knowledge in this area.

The next paper by Mr. J. Odorico and Professor C. Bathias (Aerospatiale Laboratoire Central, Suresnes, France) on selection of aircraft structural materials by use of fracture-mechanics was presented in two parts. The first, by Odorico, addressed fracture-mechanics design methodology. He stated that laboratory fracture-toughness values (K_{Ic}) may not permit prediction of structural life because the loading spectrum in service may differ substantially from that in the laboratory. Consequently, crack growth-rate data (da/dN vs ΔK) may be of little value to the designer since the mode of fracture observed in simple laboratory tension testing may differ from that observed in service. Bathias presented the results of an experimental study on the fatigue of aluminum. He pointed out that standard tests of fatigue crack-growth are not entirely satisfactory and discussed a series of experiments in which the R ratio (ratio of minimum to maximum stress) was varied while maintaining constant either maximum, minimum or mean stress. Variations in loading frequency were not considered. These results were interpreted using the Forman equation and several others. Bathias also discussed studies on the influence of overload on crack growth-rate, a procedure which was successful in slowing crack growth-rate in one aluminum alloy (2024), but not in others. He concluded with a statement

supported by many other speakers that it is absolutely essential to simulate service-loading conditions and environment.

Mr. K.H. Rendigs (VFW-FOKKER, Bremen, FRG) presented the next paper on the influence of environment and production processes on the crack-propagation behavior of unstiffened sheets. He described an experimental program in which fatigue crack-growth measurements were made on aluminum panels in both wet and dry environments. He concluded that artificial seawater had little effect on the crack growth-rate and that stretch-forming the panels to 13% prior to testing improved their crack-propagation resistance. A key point raised during the discussion was that loading frequency can have a pronounced effect on crack growth-rate in seawater environments, and that at the testing frequency used in this study, 30 Hz, less effect on crack growth-rate would be expected than if the tests were conducted at a lower frequency.

The final paper of the fracture-mechanics Conference by Mr. R. Beier and Mr. K.O. Sippel (Messerschmidt-Bälkow-Blohm, München, FRG) described an investigation of proof-load testing on 300 M steel. The authors' purpose was to determine the influence of proof-load level, holding time, and proof-test interval on crack-propagation under simulated flight loading spectrum. In theory, cracks larger than a critical value will propagate under proof-loading while those smaller than the critical value will not. Given the crack-propagation behavior of the material from laboratory tests, and crack-size estimates obtained from proof tests, it is possible to predict the lifetime of the structure or the interval of flight loadings permitted between proof tests. While there are advantages to this approach to non-destructive testing (e.g., the cost of proof-testing may be less than the cost of inspection), there are also some limitations. First, the initiation of critical flaws under proof test should be similar to that occuring under service loading. Secondly, the proof-loading should cause minimum additional damage to the structure. The authors conclude that increased safety is obtained as the level of the proof load is increased and that increased holding time under load will insure the growth of marginal cracks.

An afternoon discussion period concluded the Conference on Fracture-Mechanics Design Methodology.

While a wide range of topics was discussed with little opportunity for in-depth analysis, the Conference presented an opportunity for NATO participants to exchange ideas and assess the limitations of present design methods. The Conference as a whole provided a worthwhile insight into aircraft design philosophy. Both papers and discussions reflected the difficult transition associated with the incorporation of fracture-mechanics methods and automated analysis techniques into overall aircraft design. (Daniel R. Mulville, ONR/NRL, Washington, DC)

FLUIDS RESEARCH AT THE INSTITUTE FUR STROMUNGSLEHRE UND STROMUNGSMASCHINE IN KARLSRUHE

The University of Karlsruhe (Universität Fredericiana) has two important programs in fluid mechanics, at the Institut für Strömungslehre und Strömungsmaschine and the Institut für Hydrodynamik, respectively. The Institut für Hydrodynamik has been reported on previously (ESN 29:12); this article will refer to the first-mentioned establishment.

The Institut für Strömungslehre und Strömungsmaschine has two chairs, one in fluid mechanics, occupied by Prof. Dr. Ing. Jürgen Zierep and the other in fluid machinery, occupied by Dr. Ing. Heinz Marcinowsky. The staff of the Institut totals about 100, half of whom are technicians engaged in making apparatus and setting up experiments; of the remainder, half are engaged in fluid mechanics research and half are researching fluid machinery. The problem areas under investigation in the Fluid Mechanics Division of the Institute are hydrodynamic instabilities and transition, transonic flow, rarefied gas flows and various fundamental problems.

Both wave and interchange types of instability are studied. Wave-type instabilities occur in parallel flows having velocity distributions such that self-excited wave disturbances

of the flow can grow. It is characteristic of such flows that the self-excited disturbances have a phase velocity which lies between the extremes in velocity of the flow field. The layer where the flow velocity is equal to the phase velocity of the disturbance is known as the critical layer; there is no mass transport through the critical layer.

Interchange instabilities occur where force gradients exist. A simple example is a fluid with a stratified density distribution in the presence of a gravity field. If the density of the fluid increases in a direction opposite to the direction of the gravity force, the denser fluid will seek to interchange levels with the less dense fluid to reduce the potential energy of the system; a circulation will then ensue to accomplish the interchange. Interchange instabilities may also be driven by centrifugal force fields.

In a series of experiments under the direction of Dr. Manfred Wimmer, instabilities of flow inside and outside of rotating spheres are studied as well as flows between concentric, coaxially rotating spheres. The experiments show Taylor-Görtler (centrifugally-driven) interchange instabilities at and near the equators of the spheres and seemingly standing-wave, wave-type instabilities at latitudes between the equator and the poles; the standing-wave fronts are inclined to both parallels and meridians. It is most interesting to note that the standing-wave disturbances consist of vortices all rotating in the same direction; in an interchange disturbance the direction of rotation of the vortices alternates from vortex to vortex, while in a wave-type instability associated with a shearing layer, all vortices rotate in the same direction. The flows are made visible by suspending aluminum powder in the flow medium.

The other area of stability under investigation is Bénard (gravity-driven) convection in rectangular boxes. This is under the direction of Dr. Herbert Oertels, Jr. In these experiments temperature differences are imposed on opposite faces of rectangular boxes and the modes and mode-branchings of Bénard interchange disturbances are studied by laser interferometry. The flow media are air and silicone oil. Scanning-laser differential interferometry is used to obtain density distributions and scanning-laser Doppler interferometry is used to obtain velocity data. Soon an on-line computer will reduce data immediately as it is generated by the experiment.

Transonic flow studies are conducted in blow-down tunnels. These investigations are concerned with shock stand-off distances for detached bow shocks in front of slender bodies in slightly supersonic flows, slightly supersonic flows with high humidity and Prandtl-Meyer (corner wedge) flow with a shock in the expansion region. Data are acquired with classic Schlieren and interferometric instrumentation. A problem of particular interest under current investigation is flow about high speed sails--no doubt of importance in the field of maneuverable re-entry lifting bodies.

Prof. Bernd Schmidt directs rarefied gas studies using pure noble gases, pure diatomic gases, and gas mixtures in a shock tube. Shock structures and non-equilibrium vibrational and dissociation phenomena are studied for molecular mean-free paths up to 1 cm. Density distributions are obtained from electron-beam absorption data. The interaction of the end of the shock wave with the wall is studied along with the curvature of the shock wave at the wall. In the future, laser interferometric instrumentation will be installed to permit the acquisition of better data.

Some of the fundamental studies being conducted at the Institute concern flows with energy addition and two- and three-dimensional flow field calculations using the method of characteristics for solving the describing system of partial differential equations. The studies of flows with heat addition are performed with slightly supersonic flows of high humidity (supersaturated). The condensation of moisture liberates the heat of vaporization to the flowing fluid.

In conclusion, a lively research program in fluid mechanics is in progress at the Institut für Strömungslehre und Strömingsmaschine. (Martin Lessen)

ONRL REPORTS

See the back of this issue for a list of current abstracts.

THE AERODYNAMISCHES INSTITUT IN AACHEN

Located in the ancient city of Aachen, once the headquarters of Charlemagne, is one of the foremost Institutes of Technology in the world, the Rheinische Westfälische Technische Hochschule. The Chair in Mechanics was once occupied by Theodore Von Karman. The Aerodynamisches Institut, until recently chaired by Prof. Dr. Phil. Alexander Naumann, is now directed by the current chairholder in Fluid Mechanics, Prof. Dr. Phil. Egon Krause.

The Institut is equipped with five wind tunnels of various sizes and speeds, a hydraulic channel, a shock tube, a rarefied gas flow research facility, assorted biomedical flow test-rigs, and related instrumentation, and staffed with 30 academic and professional researchers. The activities of the Institute fall naturally into two principal classes: Classical Aerodynamics and Biomedical Flows.

The classical aerodynamics activities involve the theoretical analysis of supersonic and transonic flows about wings. *Supersonic delta planform wings* have been studied with the aim of optimizing the design of such wings with respect to potential (inviscid) and boundary layer (viscous) flow effects. Krause reported that calculated designs exhibiting drag reductions of the order of 50% from that of currently operating designs are now ready for test. The implied improvement in vehicle system transport efficiency might yet make a supersonic transport commercially feasible even in the face of escalating fuel costs!

In transonic flow studies pertaining to wings and lifting surfaces, unsteady flow phenomena and stability of transonic flows have been studied. The shock wave has been stabilized so that a stationary flow exists at angle of attack. Wing-section shapes have been evolved that are, insofar as their aerodynamic characteristics are concerned, relatively insensitive to small changes in Mach number. One of the members of the Institute, Dr. W. Kordulla is currently visiting the Ames Laboratory of NASA under an NSF Postdoctoral Grant. He is calculating three-dimensional boundary layer solutions appropriate to transonic wings in connection with the potential (inviscid) flow solutions.

There is a large research program in progress at the Institute in the general area of Biomedical Flow. Problems undertaken include blood flow in blood vessel bifurcations, secondary flow in flexible bends and acoustic diagnosis of stenosis (constriction) among others. The theoretical attack on such problems includes direct integration of the Navier-Stokes equations for small Reynolds numbers. In experimental studies, blood is being subjected to known high shearing rates to evaluate their effect on deformation and destruction of erythrocytes. In a particular test, erythrocytes are observed microscopically while flowing through a small (1 mm x 0.3 mm) rectangular cross-sectional passage, thus permitting detailed study of the deformation of the red blood cells.

An interesting form of a pulsatile blood pump is under investigation. A flexible tube, through which the blood is pumped, contains two check valves. The section of tube between the check valves is subjected to external pressure pulsations applied through a liquid surrounding the tube, thus affecting the pumping with minimal hemolysis. Various forms of valves have been researched including ball-and-plate, dish and leaflet valves. The Aachen leaflet valve consists of three leaves and is similar in appearance and function to the mitral valve. Body-compatible materials and materials having long fatigue life are under study and development. The studies in blood pumping are carried out in connection with the Department of Physiology at the University of Düsseldorf and the Department of Surgery at Aachen. The physiological effects of various pulsatile flow characteristics over long periods of time are under examination. It is known, for instance, that sustained, non-pulsatile or steady flow causes brain damage.

Prosthestic replacements for the entire ureter have been developed at the Laboratory and tested in connection with the Department of Urology at Aachen. The artificial ureter contains a check valve to prevent retrograde flow to the kidney along with a small pump to replace the peristaltic pumping function of the natural ureter. It has been found that a small centrifugal pump complete with its motor can be successfully incorporated

into the abdomen. Of course, the necessary external energy source requires that there exist a perforation of the abdominal wall, but the existence of such a perforation does not seem to be a critical problem. A more serious, long-term issue is the incrustation that takes place in the pump. It's really tough to beat nature.

The aeroelastic problem of aerodynamically induced vibrations of rooftops is being studied at the Institute both theoretically and experimentally. In these investigations, wind tunnel tests are used to obtain aerodynamic forcing functions which are then incorporated into a flutter analysis. Development of such design techniques is important as structures become more efficient and flexible due to larger unsupported spans.

The fluid mechanics associated with uranium-enrichment processes is being studied; involved are flows with strong rotation (such as those associated with centrifuges) having edge Mach numbers exceeding three, secondary flows, and pressure and concentration fields for a flow-through system.

The Aerodynamisches Institut at Aachen is in tune with the current trend of other similar institutes in entering fields such as biomechanics, where aeronautical expertise promises to solve neglected or heretofore poorly-addressed problems. Its track record indicates success. (Martin Lessen)

TURBOMACHINERY FLOW RESEARCH AT THE WHITTLE LABORATORY, CAMBRIDGE

The Whittle Laboratory was first established as the Turbomachinery Laboratory of the Engineering Department, Univ. of Cambridge, under a grant from the Science Research Council (SRC) in July 1968. In 1975, it was renamed in honor of Air Commodore Sir Frank Whittle, the inventor and early developer of the aircraft gas turbine jet engine.

The Director of the Laboratory, the distinguished mechanical engineer and thermodynamicist, Prof. Sir William Hawthorne, an early principal co-worker of Whittle's is currently the Hopkinson and ICI (Imperial Chemical Industries Ltd.) Professor of Applied Thermodynamics in the Engineering Department and Master of Churchill College. The staff of the Laboratory consists of Dr. D.S. Whitehead (Deputy Director), who is a Reader in the Department of Engineering; Dr. P.J. Watson (Laboratory Manager); six doctoral professional and faculty-level staff; four doctoral professional visitors of various ranks; ten technicians; and a full complement of research students. Besides the SRC, the Laboratory obtains support from the National Gas Turbine Laboratory (NGTL), Rolls Royce, and the Central Electricity Generating Board (CEGB). In addition to his activities in gas turbine aerodynamics, Sir William's interests cover studies in the Engineering Department in energy, heat engines, combustion processes and internal combustion engines.

Hawthorne has long been interested in secondary flow and his activity at the Laboratory reflects this particularly. A secondary flow occurs in connection with a viscous flow in a curved duct. Because the flow velocity in the center of the duct is much greater than that near the walls (the flow velocity at the walls is zero), the centrifugal force on the flow in the center is much greater than that near the walls; the center flow then tends to displace that at the outer wall, and the slow flow at the outer wall moves toward the inner wall. The net result is that besides causing a distorted axial velocity distribution, curvature in the axis of the duct also induces a circulatory or secondary flow on the plane perpendicular to the duct axis. Since turbomachinery transforms thermofluid mechanical energy to shaft work and vice versa (in the case of compressors), such machinery necessarily entails curved flow passages. Hence, curved flows and resulting secondary flows are of great importance to the turbine engineer. At the Laboratory, flows in curved rectangular cross-sectional ducts of varied aspect ratio and radius of curvature are being studied. Also, secondary flow studies in cascades (blading rows) are in progress; one such study involves a twelve-bladed cascade in a test section of 2 ft x 3 ft at velocities of 150 ft/sec. There is also a 1500-hp transonic cascade tunnel in use with flow velocities up to a Mach number of 1.4 in a 5 in. x 12 in. test section.

Some fundamental problems related to secondary flow that have been successfully analyzed deal with Beltrami or skewed flows. A skewed flow may be defined as one where successive streamlines have a continuously changing angle of direction, yet exist respectively on a set of parallel planes. The problem of simply skewed flow may be defined as a flow with a linearly changing angle of direction with distance across the flow. The problem of simply skewed inviscid flow past a circular cylinder has been solved, and by using conformal mapping techniques, the analysis has been extended to more general cylindrical shapes. In particular, the skewed flow fields about a symmetrical airfoil with no net lift and a cambered (curved) airfoil with lifting have been obtained for infinitely long airfoils. The corresponding flow field about a finite cylinder bounded by end walls has also been obtained.

The difficult, three-dimensional problem of simply skewed inviscid flow past a sphere has been solved and the results utilized in the interpretation of experimental data from five-hole impact (velocity measuring) probes. It is hoped that Sir William will compile the extensive work that he has done over the years into a monograph on secondary flow.

A number of interesting experimental investigations are underway including secondary flows, unsteady flows and asymmetries due to inlet flow distortions, noise from cascades, radial flows, three-dimensional flows, transonic cascade flows, and cascade flutter--all connected with gas turbines.

The studies in progress on the effect of inlet distortion in causing maldistribution of flow and unsteady flow in stationary and rotating cascades involve a large part of the effort of the Laboratory. One annular cascade tunnel has an inlet screen which partially blocks a portion of the inlet circumference. The performance and flow field in and behind the cascade is being examined. The rotating cascade rig in the experiment is 5 ft in diameter and the set-up includes an on-line PDP-12 computer. The Laboratory also is doing work on improving the efficiency and the performance of turbochargers for diesel engines by alleviating inlet flow asymmetries.

Unsteady flows in cascades are being studied in a cascade gust tunnel. The walls of the tunnel are flexible and movable; they can be given a prescribed displacement with time so that a sinusoidal wall wave can be imposed on the flow between the walls. If the walls are displaced 180 degrees out of phase, the flow is affected peristaltically and the cascade experiences variation in flow velocity magnitude but not direction. If the walls are displaced in phase, the direction but not the magnitude of the flow velocity is varied (to first order).

Skewed, three-dimensional boundary layers entering cascades are produced in a special cascade tunnel with a moving belt wall and are used in the study of the effect of such flows on cascade performance.

There is an experiment involving flow in a rectangular duct rotating about an axis perpendicular to the duct axis. The Coriolis effect induces an overall secondary flow in the duct similar to that in a stationary curved duct. In addition, the boundary layer flow along the duct walls is subjected to a Coriolis effect that causes a Görtler-like (centrifugally-driven) instability in the boundary layer flow. Indeed, it seems that the Görtler instability would be a major source of losses in curved turbomachinery flow passages.

A new experiment being set up in the Laboratory is designed to investigate the flow about trains in tunnels. A curved train model is mounted on the rim of a disk and a curved tunnel without a floor is placed against the disk rim so that sensors in the train model and tunnel can observe the entry of the train into the tunnel and steady flow effects. With appropriate train models mounted on adjacent counter-rotating disks and a suitable tunnel model, the effect of high-speed trains passing each other in a tunnel can be investigated. An obvious though perhaps minor deficiency in the experiment, however, is the fact that the tunnel floor is lacking and the moving disk therefore induces a flow in the tunnel before the model enters.

A small rotating cascade tunnel is set up to study noise from a rotating

cascade, while another 5-ft diameter rig is being used to study rotating cascade blade flutter. Two small set-ups which are being used as student exercises but which also could serve as research equipment can study various rotor-stator combinations in axial and radial flow respectively.

In all, it was most enlightening to visit the Whittle Laboratory--a research facility of the SRC--and to observe the quality research directed at real engineering problems. (Martin Lessen)

PHYSICAL SCIENCES

INTERNATIONAL CONFERENCE ON SUPERCONDUCTING DEVICES

The first International Conference on Superconducting Quantum Devices and Their Applications (IC SQUID) was held in West Berlin, Germany, 5-8 October 1976. The meeting was sponsored by the European Physical Society and the Physikalisch Technische Bundesanstalt (PTB)--the German equivalent of the US National Bureau of Standards--with the Institut Berlin of the PTB acting as the host organization. There were approximately 130 attendees from 11 countries with the host country represented by 40, the US by 20, and France, Italy, The Netherlands and United Kingdom, each by about one dozen scientists. Other countries represented were Switzerland, Finland, Denmark, Japan and Czechoslovakia. The USSR, where there is a sizable activity in SQUIDs, was not represented at the meeting, although two papers had been submitted by researchers working at the Ukranian Academy of Sciences in Kharkov.

During the conference 9 invited and about 45 contributed papers were presented. The meeting extended over four days with no parallel sessions. Of the 9 invited papers, 6 were from the US with 5 of these being given by scientists who are either funded by ONR or work for the Navy. This fact again emphasizes the major role that the Navy and ONR, in particular, have played in the development of SQUIDs. (For background and a very readable introduction to SQUID research, see "The Care and Feeding of SQUIDs" by T.A. Kitchens, ESN 30-2:86.)

Although very little new material was presented, the Conference, taken as a whole, did provide a good review of the physics and technology of many aspects of the Josephson junctions and the use of these devices, in particular for the measurement of low-frequency magnetic fields. Therefore, in summarizing the meeting, only a few papers will be cited which deal with device fabrication technology, computer modeling of SQUID systems, refrigeration and some applications.

Several papers were presented which reinforced the impression gained during the past few years that the tunnel junction with an oxide barrier has re-emerged as a viable Josephson structure. The early experimental verification about fifteen years ago of the predictions made by Josephson was done on oxide tunneling barriers--the configuration that had been treated theoretically by Josephson. However, these structures quickly fell out of favor as they were not very reliable under temperature cycling and, furthermore, did not store well at room temperature. Thus "weak links"--point contacts, Dayem constrictions, thin films with localized regions of suppressed superconducting transition temperatures, etc.--were devised for use in laboratory instruments and experiments. However, these latter devices are pseudo-Josephson junctions, and their behavior does not conform strictly to the predictions of the tunneling theories of Josephson and others. Nevertheless, most experimentalists, except possibly those working on the Josephson voltage standard, abandoned the oxide tunneling barrier for the "weak links" which tended to be more reliable and perform better under thermal cycling. Several years ago, Clarke (UC-Berkeley) went back to the oxide barrier and fabricated niobium/niobium oxide/lead structures for use in double junction DC SQUIDs whose performance in terms of magnetic flux noise was superior to the more popular single-junction RF SQUID. At this meeting there were several papers relating to the fabrication, properties and application of circuits using oxide-barrier tunnel functions.

There were two papers from IBM-Zurich dealing with the fabrication

and use of oxide-barrier devices in computer circuits. The IBM groups at Zurich and at Yorktown Heights have advanced Josephson tunnel junction technology to the point where they can now fabricate chips with as many as 60 Josephson devices connected by superconducting transmission lines which can perform useful data processing operations, both arithmetic and memory. In addition to making these circuits with close tolerances on electrical properties, these chips can be temperature-cycled between cryogenic and room temperature without degradation. Stabilization is achieved using a patented alloy consisting of 3% Au, 12% In and 85% Pb. The Josephson junctions are used either as single-element switching devices or in interferometers with two or three junctions. The finished chip may have as many as eight to ten layers of superconductors and insulators, with the patterns for each of the various layers prepared by scanning electron-microscope exposure of photoresist coatings. The primary advantage of Josephson technology, according to the IBM researchers, is that delay times of the order of 100 psec and power dissipation of less than microwatts can be achieved simultaneously. With conventional semiconductor technologies, each of these characteristics can be achieved separately but not at the same time. IBM is treating their development with a very strict proprietary attitude, but the little that they have made public both at IC SQUID and at other meetings, such as the Applied Superconductivity Conference held at Palo Alto, CA, last August, is very exciting, and this work will be followed with great interest.

Another very interesting paper on oxide-barrier junctions was presented by J. Neimeyer and V. Kose (PTB-Braunsweig) dealing with the characteristics of very small-area tunnel junctions. The devices were lead-indium/lead-indium oxide/lead structures with rectangular cross sections ranging in area from 100 μm^2 down to 3 μm^2, the latter devices having tunneling barriers of the order of 1 μm on an edge!! Even for the smallest junctions (those with the highest value of pair current density) the Josephson penetration depth was about twice the junction length, and thus the current flowing through the junction at zero-applied magnetic field could be assumed to be uniformly distributed. The measured values of critical current density ranged from 10^2 A/cm^2 for the larger junctions up to 10^5 A/cm^2 for the 3-μm^2 devices. These data, which spanned three orders of magnitude and thus a much wider range than previously reported for similar studies, were compared to the shunted junction model of D.E. McCumber [*J. Appl. Phys.* 39, 3113 (1968)] and to recent calculations of D.G. McDonald *et al.* [*Phys. Rev.* B13, 1038 (1976)]. The fit was fairly good to both theories for the high-current density data, but there were pronounced deviations for the low-current data. One of the most encouraging observations of these experiments was that very small reproducible tunnel junctions with high values of critical current density and minimal hysteresis could be prepared. These latter features may open up the possibility of using oxide-barrier tunnel junctions for the detection of high-frequency radiation. The RC time constant of these devices corresponds to a frequency of the order of 1000 GHz, and the devices have normal-state resistances of the order of ohms. Weak-link detectors, whether point contacts or thin films, tend to have normal-state resistances less than 1 ohm thus presenting severe problems for impedance matching to either free space or waveguides.

In recent years, scientists working with thin-film weak links have realized that not only must the structures have dimensions of the order of 1 μm or less, but one must also be capable of making three-dimensional weak links, the so-called "variable thickness bridge" (VTB), in which the bridge region is much thinner than the adjacent pads. This geometry permits heat and other manifestations of nonequilibrium phenomena produced in the bridge region to diffuse away, thereby improving high-frequency performance. The "double scratch" technique developed by M.P. Levenson and P.E. Lindelot (H.C. Oersted Institute, Univ. of Copenhagen) [*J. Low Temp. Phys.* 1, 99 (1972)] or variations of that technique have been used to produce very small structures in films of the soft superconducting materials. However, this procedure cannot be applied to the refractory materials such as niobium and its alloys. Hence the problem of producing weak links with predetermined and controlled geometries

in both soft and refractory materials has been attacked by a number of groups. The group from the State University of New York (SUNY) at Stony Brook under J. Lukens has employed some of the very sophisticated techniques common in the semiconductor microcircuit industry. The films are coated with electron-sensitive photoresist materials, such as polymethylmethacrylate (PMM), and a computer-controlled scanning electron-microscope (SEM) is used to write the desired pattern into the resist coating. Once the exposed portion of the resist has been removed, the film underneath the exposed photoresist is removed by ion-milling or sputter-etching. This procedure is capable of producing lines with widths down to 0.1 to 0.2 μm. The advantage of this procedure is that it can be applied to all materials of interest, although the milling rates may vary from material to material. The principal disadvantage is the very large capital equipment investment for the acquisition of the ion-milling equipment and the scanning electron-microscope.

Using this technique, the SUNY group has prepared indium variable-thickness bridges with dimensions of the order of 0.2 μm using overlaid films. In the fabrication process the underlying films must be carefully cleaned using ion-milling before the overlying films are deposited to avoid surface contamination problems. An added advantage is that, once the structure has been fabricated, the SEM can be used to examine the device. It is obvious that every laboratory working in Josephson devices ought to have such an instrument!

An interesting new device concept was described by S. Takacs (Electrotechnical Institute, Bratislava, Czechoslovakia). Takacs and coworkers have fabricated weak-link devices in which the bridge is a long superconducting thread having a diameter of 20 μm. The device is fabricated by depositing lead or tin electrodes on both sides of a thin (about 20-μm) silicon membrane; the thread connecting the two superconductors is formed by electrical pulse breakdown. The critical temperature of the thread is about 0.1 K higher than in the bulk regions, and the typical normal state resistance is 10^{-2} Ω. The usual radiation-induced steps are observed at 10 GHz when the bridge lengths are approximately 20 μm, indicating the existence of the ac Josephson effect. Since the bridge length is much larger than the coherence length, these results can be interpreted in terms of coherent vortex motion. For longer threads of the order of 200 μm, no radiation-induced steps are observed. An interesting study of the influence of magnetic fields on the ac Josephson effect was explainable in terms of the vortex lattice being accommodated within the bridge regions.

One topic usually overlooked at most meetings on small-scale superconducting devices is that of refrigeration. J.E. Zimmerman (NBS-Boulder) reviewed various refrigeration schemes that might be used to cool Josephson devices and then described a very small, low input power, Stirling cycle refrigeration system he is presently trying to perfect. The low temperature parts of the system are made of nylon and fiberglass in order to minimize magnetic noise in the vicinity of the cold station. With electrical input power of tens of watts, he has been able to produce temperatures in the neighborhood of 15 K. The cooling capacity of this type of system is very small, but this is acceptable as SQUIDs dissipate approximately a μW or less of heat. In the near future, Zimmerman will determine whether the magnetic signature of the system is adequately small so as not to degrade the performance of the overall SQUID system mounted on the cold finger and also determine whether there is any flexing of the system during the piston stroke that would cause the sensor to move in the earth's field and thus result in magnetic noise. If this type of refrigeration system can be perfected and can be coupled successfully to a Josephson sensor, the use of Josephson devices outside the laboratory could be made extremely convenient.

There were a number of papers at the conference dealing with "modeling" or computer-simulation of Josephson-effect devices including SQUIDs. These approaches usually assume that there is an ideal Josephson element shunted by a constant resistor plus an assortment of other conventional circuit elements. These calculations have been fairly successful in accounting for the response of devices to incident

electromagnetic radiation. However, only marginal insight into the physics of Josephson devices can be learned from these calculations, no matter how complicated they may be or how sophisticated the mathematics that must be employed to solve the equivalent circuit models. It would appear that theoreticians should put aside circuit analysis and attack from a fundamental viewpoint the physical phenomena responsible for the behavior of weak-link structures. There has been some published work in this direction by scientists in the USSR, but unfortunately there were no attendees from that country to report on this work.

Finally, in the area of applications of SQUIDs--recall that the title of the Conference was "SQUIDs and Their Applications"--there were papers dealing with already well-known applications such as voltmeters, magnetometers, susceptibility meters, calorimetry, dc current comparators, instruments to measure rf attenuation, etc. An application that has not been previously described in an open scientific meeting was the use of SQUIDs in an ELF submarine communications antenna. This antenna, being developed at the Naval Research Laboratory (Washington) has been operated at remote sites, both on the surface and at depths of 100 m below the surface of the ocean to receive signals in the frequency band between 30 and 130 Hz. Although this application *per se* is of very little interest outside of the military, the demonstration that SQUID systems can be built that will operate at remote and environmentally hostile locations is most encouraging, because this implies that SQUID instruments can indeed be brought out of the low-temperature laboratory to be operated and used by non-specialists. [Martin Nisenoff (NRL) and Richard Brandt (ONR-Pasadena)]

1976 INTERNATIONAL CONFERENCE ON MAGNETISM

The 1976 International Conference on Magnetism (ICM'76), held 6-10 September 1976 in Amsterdam, was the seventh in a series of triennial ICMs co-sponsored by the International Union of Pure and Applied Physics (IUPAP) and a prominent scientific organization of the host country. Although ICM'76 was preceded and followed by a record number of ten satellite conferences, four of which were sponsored by IUPAP, its coverage included essentially all the sub-areas of the field of magnetism.

The emphasis of ICM'76 was on the basic rather than applied aspects of the field. Contributing to this (partly intentional) imbalance was the date of the more applications-oriented Joint MMM-Intermag Conference (held in Pittsburgh, PA) which preceded that of ICM'76 by only three months. Another contributing factor may have been the recent upsurge of solid-state research in Western Europe.

The number of registered participants at ICM'76 was approximately 1000, representing 34 countries, the largest delegations after The Netherlands, nearly 200, coming from France (158), West Germany (121), United States (101), United Kingdom (86), and Japan (62).

Listed in the program were nearly 700 contributed papers and 33 invited papers, an increase over previous ICMs but at a slower rate. Of the contributed papers, about 55% were presented in the familiar oral format (i.e., as 12-min lectures) and the rest were given in so-called "poster sessions", a format pioneered by other scientific conferences but not used in any previous ICM. A typical morning or afternoon began with two parallel invited sessions consisting of two papers each. These were followed by ten parallel contributed sessions which were about evenly divided between the "oral" and "poster" types. Extensive "session hopping" was greatly facilitated by the short distances between lecture rooms and by the availability of an electronic system for monitoring the progress of all simultaneous sessions.

The contributed papers were presented in 82 sessions. Apart from a few cases (e.g., "3d Intermetallics I, II or III"), the titles of these sessions were all different and thus too numerous to be listed here. An attempt has been made, therefore, to classify the session titles into a smaller number of categories which describe, in most cases, types of materials rather than phenomena or methods. Although the resulting 17 categories (which do not distinguish between theory and experiment) are neither unique nor entirely consistent, it is hoped that they will provide a useful indication of the topics

discussed at ICM'76. The list which follows gives the titles of these categories and, in parentheses, the number of sessions assigned to each category.

Magnetic insulators (16½), Transition metals and their alloys (13), Critical behavior and phase transitions (6½), One- and two-dimensional magnetism (6), Rare-earth-transition metal alloys (5½), Dilute alloys (5), Domains and small particles (4), Magnetic Semiconductors (3½), Amorphous and disordered materials (3½), Spin glasses (3), Metal-insulator transitions and intermediate valence (3), Rare-earth metals and their alloys (2½), Surface magnetism (2), Rare-earth-non-transition metal alloys (2), Singlet ground-state systems (2), Exchange (2) and Miscellaneous theory (2).

Among the general impressions conveyed by the contributed papers is the rather considerable effort which is being devoted in France to the development of magnetic materials, some of which are new. The main centers of this effort are in Grenoble, in the Paris area (Bellevue, Orsay and Saclay) and in Talence. Also worth mentioning are the interesting contributions from the joint English-French-German neutron diffraction facility at the Institut Laue-Langevin in Grenoble, which was completed only recently. In an invited paper from this Institute, F. Mezei described recently-developed techniques for fully exploiting the vector character of the neutron polarization.

The invited papers were well chosen and gave a reasonably good account of the present status of magnetism. Particularly impressive and useful was the fact that they tended more to being reviews (or even tutorials) than detailed reports of the authors' latest achievements. It was most unfortunate, but probably unavoidable, that a given participant could attend only half of the invited papers. Although the scheduling was generally excellent, a total elimination of serious conflicts appears to be an unattainable goal: In a session I chaired, Yu. P. Irkhin (Sverdlovsk, USSR) gave an invited paper on "Magnetics with High Anisotropy" (dealing with rare-earth-cobalt alloys) while in the parallel session J. Jensen (Oxford Univ., UK) gave a concurrent invited paper on "Two- and Single-Ion Magnetic Anisotropy in the Rare-Earth Metals".

Without attempting to select the "best" among the many invited papers of high quality, this participant was particularly impressed by the clarity of the following four presentations:

R.J. Elliott (Oxford Univ., UK) discussed "The Cooperative Jahn-Teller Effect and Related Problems", a subject of considerable recent interest. In analyzing a system containing Jahn-Teller ions, he used a Hamiltonian containing not only a crystal field term and a phonon term but also a crucial interaction term which describes the coupling between the electronic and vibrational motions. By transforming to "displaced phonon operators", he then showed that the resulting form of the Hamiltonian reveals an effective interaction between different electronic multipoles. If only one multipole operator (which can sometimes be expressed in terms of a pseudo-spin) is important, then the use of molecular field theory allows one to estimate the temperature at which the system exhibits a phase transition to a state in which the electronic multipoles are ordered. The phase transition occuring in the cooperative Jahn-Teller effect (CJTE) is analogous to a spin-ordering transition in magnetism. Elliott pointed out that the required condition for the CJTE transition temperature is either a "soft mode" or a "central peak". He then reviewed experimental and theoretical work on the CJTE in the rare-earth zircons (e.g., $DyVO_4$ and $TmVO_4$) and other materials. Also mentioned were effects related to the CJTE, including: phase transitions in ferroelectrics and singlet ground-state magnets, structural phase transitions in narrow-band metals (such as the A15 superconducting compounds), and the Peierls transition in a one-dimensional metal.

"Recent Developments in Critical Magnetic Behavior" were reviewed by A. Aharony (Tel-Aviv Univ., Israel). The central theme of his paper was the impact of renormalization group techniques on our understanding of critical phenomena. This is a difficult but promising subject which is not well known outside the circle of its practitioners. Using an approach different from that of Elliott, Aharony did not attempt to give any derivations but concentrated on results, especially on those obtained since ICM'73. The topics discussed included crossover

phenomena, competing interactions and multicritical points. Particularly interesting is the case of uniaxial dipolar systems in which the number of dimensions, d, has the value 3. In this particular case the renormalization group technique makes it possible to calculate exactly the singular term in the specific heat and in the susceptibility. Aharony pointed out that the recent experimental confirmations of these results in $LiTbF_4$ constitute the first experimental verification of renormalization group theory. In general, however, he feels that theory is far ahead of experiment even though most of the calculations use an expansion in 4-d and thus give only qualitative results for d = 3.

In his summary of "Experimental Studies of Multicritical Points in Magnetic Systems", W.P. Wolf (Yale Univ., US) reviewed magnetic phase transitions in tricritical as well as bicritical systems. The former include certain highly anisotropic antiferromagnets ($FeCl_2$, $CsCoCl_3 \cdot 2D_2O$ and $Dy_3Al_5O_{12}$) and the latter include certain weakly anisotropic antiferromagnets (MnF_2, $GdAlO_3$ and $NiCl_2 \cdot 6H_2O$). In both kinds of systems the agreement between theoretical predictions and experimental results is generally good. Wolf believes that most of the remaining discrepancies can probably be attributed to experimental difficulties such as non-uniform demagnetizing fields and inaccurate alignment of the applied magnetic field with respect to the crystalline axes of the sample. Although these difficulties are hardly unusual, their influence on studies of multicritical point behavior appears to be particularly strong. It is noteworthy therefore, that the experimental problems can be avoided by "replacing" the experiments with Monte Carlo-type computer studies. While this "alternative" has the additional advantage that it allows one to apply "staggered" as well as uniform fields, it suffers under the severe limitation of finite (and relatively small) sample size. Wolf noted that the largest system studied so far with a computer had 20 x 20 x 20 spins and that the extrapolation from this number to infinity is still quite difficult. He hoped that materials will be found in which the experimental problems are less serious and that the Monte Carlo studies will be extended to larger computers.

A critical review of various concepts and theories of "Spin glasses" was presented by K.H. Fischer (Kernforschungsanlage Jülich, FRG). Also discussed in his paper were appropriate experimental results on magnetization, static susceptibility, specific heat, resistivity and neutron scattering. Fischer introduced spin glasses by recalling that in a series of alloys, typically noble metals with a few percent 3d transition-metal impurities, the measured static susceptibility exhibits a sharp cusp at a certain temperature T_f which is known as the "freezing temperature". This cusp is a typical spin-glass property. It has been explained by the assumption that at temperatures below T_f the spins in such alloys point along randomly oriented local axes. Mössbauer studies suggest, in fact, that below T_f the spin directions are random, and neutron scattering experiments indicate the absence of any long-range order. Remanence effects, after-effects and asymmetric hysteresis loops have also been observed, but the nature of the required energy barriers is not yet known. Also lacking is a set of generally accepted conditions which are truly necessary for spin-glass behavior. (It should be noted that systems containing chemical clusters are sometimes referred to as "mictomagnets".)

Although recent theories have advanced our understanding of spin glasses considerably, Fischer emphasized that several important problems are still unsettled. It is not clear, for example, what type of phase transition (if any) is indicated by the phenomena occuring at T_f, notably by the presence of a cusp in the susceptibility and by the absence of an anomaly in the specific heat.

It is a pleasure to report that the organization of ICM'76 was truly superb. The "Conference Program and Abstracts" booklet arrived in the US as early as two months before the Conference began, and the Conference Proceedings are scheduled to be published in *Physica B*, a widely available Europhysics Journal. (Recent experience shows, unfortunately, that neither of these accomplishments is trivial.) The facilities of Amsterdam's International Congress Centre were ideally suited for the many parallel sessions and other requirements of ICM'76, and

it seems fairly safe to say that everything had been foreseen and everything really worked. An excellent spirit of friendliness and hospitality pervaded the scientific sessions as well as the social events, and the international magnetism community surely owes a debt of gratitude to Professor G.W. Rathenau, the President of ICM'76, and to Professor G. de Vries and his colleagues on the ICM'76 Management Committee. (George T. Rado, NRL)

INTERNATIONAL CONFERENCE ON MAGNETO-OPTICS

An International Conference on Magneto-Optics (ICMO), a satellite meeting of the International Magnetism Conference in Amsterdam, was held 1-3 September 1976 at the Swiss Federal Institute of Technology (ETH) in Zürich-Hönggerberg under the auspices of the European Physical Society's Magnetism Section of the Condensed Matter Division and the International Union of Pure and Applied Physics (IUPAP). The aim of the Conference was to bring together scientists working in the field of Magneto-Optics in order to discuss various aspects such as methods of measurement, experimental and theoretical research, and applications.

As might be expected, the work reported was predominantly European research, but there was a substantial contribution by the US (17%) and Japan (11%) to the 58 papers presented. There were few participants in addition to the authors of the papers, so that the Conference remained small enough to encourage easy communication. Although techniques were touched upon in a few papers, very little new was introduced. Most speakers assumed the established procedures were well known and went on to discuss the research results directly. This had the result of grouping the Conference interests about the solid-state materials under study: 80% of the work reported was almost evenly divided between semiconductors and magnetic insulators. The remainder was fairly evenly divided between metals and applications, largely integrated optics.

There were a few experimental innovations which could have application to materials studies beyond those presented at the Conference. The Institute for Solid-State Physics at the University of Tokyo [G. Kido, N. Miura, K. Kawauchi, I. Oguro, J.F. Dillon, Jr. (on leave from Bell Labs, Murray Hill), and S. Chikazumi] is employing pulse techniques to generate megagauss fields. These fields were generated by the compression of the injected magnetic flux with a rapidly compressed metal ring liner. The liner is imploded by the steeply rising current at a one-turn coil which encloses the liner coaxially.

At the University of Bordeaux (Yves Servant, Laboratoire d'Optique Ultra-Hertzienne, Equipe de Recherche Associée au C.N.R.S.) there has been developed a new approach to electron paramagnetic resonance (EPR) which measures relative absorption vs. phase shift at microwave frequencies which should be especially useful for detecting very broad lines in the presence of sharp, strong resonances.

Workers from the University Complutense in Madrid (C.N. Afonso, F. Briones, J.L. Vicent, Laboratorio de Magnetismo) described a new experimental method for measuring second-order magneto-optic effects in reflection from ferromagnetic metal films in which a rotating magnetic field is applied in the sample plane. The even effects, which are proportional to the square of the magnetization component perpendicular to the plane of incidence of the light, can be separated from the background of the usual odd Kerr effect by tuning a lock-in amplifier to the second harmonic of the applied modulated field.

Finally, work at the Naval Research Laboratory in Washington, DC (G.A. Prinz, R.J. Wagner, C. Vittoria and J. Schelleng) has demonstrated that mm-wave radiation from optically pumped molecular gas lasers can be successfully employed to observe ferromagnetic resonance in metal films. The multi-frequency output from these lasers means that it is no longer necessary to use several expensive, short-lived electron tube sources in this region of the spectrum for even difficult resonance experiments.

The proceedings of the Conference will be published in *Physica B* early in 1977. (Gary A. Prinz, NRL)

EIGHTH INTERNATIONAL COLLOQUIUM ON MAGNETIC "THIN" FILMS

The Eighth International Colloquium on Magnetic "Thin" Films (ICMTF), held in York, England, 15-18 September, had more than 80 participants from at least 14 countries including four Eastern European countries: USSR, Poland, Hungary, and Romania. The conference was organized and handled by the local organization committee under the chairmanship of M. Prutton, Physics Department, University of York. The overall objectives of this meeting were to provide (a) an opportunity to review and discuss new ideas and current research in magnetic films and film surfaces, (b) to bring together those working in the basic and technological aspects of film research, and (c) to maintain the ICMTF tradition of stimulating discussions in an informal atmosphere. In order to meet these objectives, the Conference format was composed of two parallel sessions with ample time for discussion at either the end of each session, or in one of the parallel sessions set aside for the discussion of areas of common interest.

Although the meeting covered a wide cross-section of topics pertaining to magnetic films in various states, and of various crystal structures (e.g., interfacial effects in bubble devices, mobility of bubble domains, catalysis at magnetic surfaces, Mössbauer spectroscopy, photon-magnon scattering, and scanning electron microscopy), there was particular interest in the magnetic properties of film surfaces, both from a theoretical as well as experimental point of view. The old subject of dead magnetic layers on magnetic film surfaces became the subject of a lively discussion. There were many contributed papers and one invited paper in this area. Most dealt with the problem of composite magnetic films, i.e., magnetic films sandwiched between two non-magnetic film layers such as the substrate (usually glass) and another non-magnetic substance such as copper, gold, etc., deposited on the surface. It was generally concluded that the deposition of the non-magnetic materials may result in dead magnetic surface layers at the surface of the magnetic film. That is, the interaction at the surface is such that the surface layers of the magnetic material may no longer be magnetic, at least for several atomic layers.

D.M. Edwards (Dept. of Mathematics, Imperial College, Univ. of London) pointed out that the dead layer effect, at least in the case of nickel, could be due to: (a) surface states split from the top of the majority spin band owing to the modified exchange potential at the surface, and (b) an increase in the number of minority spin and electrons in the surface layer due to a modified surface density of states. Edwards also pointed out that in some materials an enhanced surface magnetism is possible.

The study of surface magnetism and the magnetic properties of surfaces, which is very exciting from a theoretical point of view, will also contribute to a better practical understanding of catalytic processes. However, there are many experimental and analytical problems to be surmounted before real progress can be made. One of the basic problems is determining the thickness uniformity and physical properties of dead or live layers. According to H. Hoffmann (Fachberich Physik Univ. Regensburg, FRG), this problem is difficult if not impossible to resolve at the present since most analytical probes are designed for bulk measurements rather than for single atomic layer materials. Basically, what is needed is a probe which has a wavelength of the order of one atomic layer.

Auger spectroscopy was demonstrated to be a useful tool in the study of interfaces between two films. Future research in films will make more use of this tool. The Auger work of K.Y. Ahn (IBM, Yorktown Heights, NY) on Gd-Co films revealed for the first time that there is high concentration of oxygen at the film surface and at the film-glass interface. He demonstrated that if Si is evaporated onto the glass before depositing Gd-Co, the oxygen content at the film-silicon interface is dramatically reduced. He also found that pre-evaporated gold and titanium were not as "good" as Si in reducing the oxygen content near the glass. The Auger data may shed light on the excitation of magnetic surface states-excited by FMR techniques.

Ten years after the birth of magnetic bubble technology, special attention was put by Dr. W. Doyle (Sperry Univac, Blue Bell, PA) on the effect of a diffusion zone which can exist

between a magnetic film and a substrate. Doyle cited recent Auger work of researchers at NRL and IBM as evidence for the existence of a diffusion zone. The magnetic properties in the diffusion zone change gradually from the values found in the bulk. Doyle pointed out that a diffusion zone can influence the bubble dynamics, such as the bubble velocity and frequency response. Bubble materials are now being considered for high density memories for computers.

Because of the considerable interest in magnetic film surfaces, the conference has been renamed the International Colloquium on Magnetic Film Surfaces. The next Colloquium will be held in Poznan, Poland, 3-8 September 1979 and hosted by Professor Wojtcak, Univ. of Lodz, Lodz, Poland. (Conrad M. Williams and Carmine Vittoria, NRL)

TECHNOLOGY

VIEWDATA AND TELETEXT

In Britain the idea of data terminals in the homes of the general public is more than mere talk; two complementary approaches, called "Teletext" and "Viewdata", are currently undergoing experimental tests with the cooperation of British electronic manufacturers and news, financial, travel, and educational organizations as well as the TV broadcasters and the Post Office. (The British Post Office took over telegraphy from private industry in 1868 and telephony in 1912.) These new concepts are altogether different from that of "Viewphone", the British Post Office's equivalent of the Bell "Picturephone", which would require a special cable with 0.5- to 2-MHz bandwidth, and which the Post Office has shelved in favor of "Confravision". (The latter offers special conference studios in various cities connected by two-way closed-circuit TV with high-quality split images showing the participants or their visual materials on both sides of the conference.)

In contrast to Viewphone and Confravision, Teletext and Viewdata are digital systems that use a modified color or black-and-white TV set to display information received, respectively, from a TV transmitter or over a regular telephone line. Teletext is intended for the quick delivery of any of up to 800 pages of relatively perishable information to a large audience. Viewdata, on the other hand, may offer 70,000 pages of stored information, which can be selected interactively by the user. The combination of these two different systems is intended to provide a wide range of useful services through the same modified TV set, including news, timetables, catalogs, telephone directories, business information, technical data, reservations, mail-order shopping, computer-aided instruction, message transmission, and computation--all readily accessible without any training course or user's manual.

In both Teletext and Viewdata, the display page consists of 24 lines of 40 characters, which are transmitted asynchronously with 8-bit ASCII coding plus start and stop bits. Each Teletext or Viewdata page is equivalent to a quarter of a page of single-spaced typing or 1/75 of a page of a full-sized newspaper.

The circuitry added to the TV set provides the necessary storage, translation into 5 x 7 dot matrices, display control, etc., including display of a blob if the parity check carried by one of the 8 bits fails (this blob permits the Viewdata user to request a repetition if necessary). The added circuitry also enables the user's keypad to select the desired page of Teletext material or to communicate over the telephone line with the local Viewdata computer--or, if necessary, with one in another city.

With the aid of the two-way telephone line, Viewdata can not only retrieve information from large, slowly changing data banks but can also be used to send messages to other users, to retrieve personal messages that have been left, to make reservations, to perform computations beyond the scope of a pocket calculator, and to provide interactive instruction.

Despite its versatility, the Viewdata system is designed to be no more difficult to use than the telephone. Thus, there is no user's manual, and there is no need for one. At each stage the user is shown a list of only as many alternatives as he can reasonably cope with and the response he must make to obtain each. The system

is designed to be sympathetic and helpful, avoiding surprises that might discourage the user. At the same time, the experienced user can go directly to the part of the system he wants without having to read his way through the selection tree. The ease with which Viewdata can be used makes the system especially attractive for wide application by the public.

Teletext employs the time during vertical retrace on regular TV broadcasts (while the electron beam is returning from the bottom of the screen to the top) to transmit data via raised-cosine pulses at the rate of 6.9375 Mbit/sec. With 32 otherwise blank horizontal lines (during vertical retrace) out of the 625 lines per TV frame used during each 40-msec frame for data transmission, it takes 0.03 sec to transmit a page and 24 sec to transmit the entire set of 800 pages sequentially. Thus, the Teletext user will, on the average, get the page he wants 12 seconds after he has requested it, and it will appear instantaneously when it comes. (In the US an approach similar to that of Teletext has been considered for captioning the accompanying TV program as an aid to the deaf.) A Viewdata page, on the other hand, should begin to appear within 2 seconds after it is requested, the maximum time needed to retrieve it from disk storage. Although it may take up to 8 seconds to be completely displayed, since data arrive at 1200 bit/sec over the telephone line, the user can begin reading immediately from the top of the screen. (Pages that are partly blank will take less than 8 seconds.)

Television is broadcast in Britain not only by the BBC, which has two networks, but also by ITV, a commercial network operating under the Independent Broadcasting Authority (IBA). The foregoing description of Teletext applies precisely only to the IBA's experimental version, called "Oracle". The BBC's version, called "Ceefax" (for "see facts"), currently uses only 4 lines per TV frame for data and thus transmits only a 100-page magazine, in contrast to Oracle's 800 pages. A fully dedicated TV channel could bring Teletext up to 30,000 pages or more, enabling it to provide a full selection of sporting results, stock quotations, advertising, and much more. It is interesting to note that news services are already operating seven days a week to provide inputs for the experimental Oracle and Ceefax systems, and the 100-page Ceefax repertoire is augmented, for example, by presenting three different weather maps sequentially (every 24 sec) on the meteorological page.

Two kinds of keypads resembling pocket calculators are under test for Teletext page selection and Viewdata communication. One of these has only the standard 12 telephone buttons (0-9, *, #) and the other has 40 keys, including alphabetic, mathematical, and control keys. For Viewdata they communicate to the computer at the rate of 75 bit/sec in the duplex mode, with simultaneous transmission at 1200 bit/sec on different frequencies in the opposite direction, i.e., from the computer. The computer "echoes" (repeats) each character it receives, and the user's terminal then displays it. This form of operation permits the user to correct an error immediately, to return to the previous page, or to start immediately all over again; and it gives him confidence that his messages are being received. Duplex operation is also important when the computer is transmitting data to the user, as it permits him to interrupt at any time to ask for something new or to log off (i.e., to end the session) without having to pay for the time required to transmit the rest of the page. Logging off, in fact, requires only that he hang up. To reduce the cost of the equipment, however, consideration is being given to the possibility of using half or three-quarter duplex operation, in which data would flow in only one direction at a time at both ends or at one end of the communication link.

Computers are not new to the British Post Office; it has been offering data-processing services to industry for some time and has been operating the "Giro" system of automatic funds transfer for about ten years. In the Viewdata application there would be a computer with perhaps ten 20-Mbyte disks, holding 200,000 pages altogether, within the local calling area of every large city (1 byte = 8 bits). Several of these local centers would be grouped into each regional center, communicating among themselves at the rate of 2400 or 9600 bit/sec, mainly to update the local files. The regional centers, in turn, would be linked by 48-kbit/sec

lines to a national center, principally for transmitting information of high value that is likely to change frequently and that therefore will not be stored at the local centers. The current tests, which began early in 1976, however, use only a single computer at the Post Office Research Centre, which is accessible by local and long-distance telephone connections.

These tests involve 50 to 100 Viewdata terminals--several of them in France, The Netherlands, Germany, and Scandinavia with the TV adapters built locally in each case. The tests are intended to refine the system, to enable the TV industry to try out its adapter designs, and to develop the procedures for compiling, editing, and updating the stored information. The Post Office is paying the entire cost of the tests except for the development of TV terminals (supported by the TV industry) and the provision of information, which is funded by those who provide it. When Viewdata goes public the organizations which provide the information will be paid in accordance with the amount of use made of their data. In March 1978 a market trial will begin, involving over 1000 Viewdata terminals. If the response is favorable and the costs of the equipment and services turn out to be acceptable, the market trial will gradually merge into full-scale public operation.

Mr. Samuel Fedida heads the Computers and Mathematics Division of the Post Office Research Centre, Martlesham Heath, Suffolk, in which the Viewdata work comes under Mr. K.E. Clarke and Mr. J. Rao. Viewdata owes its conception and development chiefly to Fedida's innovativeness, energy, and enthusiasm. He expects each local center to be able to handle 10,000 or 20,000 users, 300 or 400 at a time, on the assumption of 5 minutes use per day by each.

While the experimental test of Viewdata is going well, many possible improvements are being considered, such as the doubling of the 1200-bit/sec rate of communication from local center to user, the addition of a tape-cassette recorder to the TV adapter in order to permit the retention of material without incurring a continuing charge for the use of the telephone connection and to allow the recording of news and messages at high speed when the user may be away or asleep. In addition, the keypad cable might be replaced by an ultrasonic link to the adapter. Provision has already been made for the transmission of pictures, e.g., of a cake and candle as part of the standard birthday-greeting message available through Viewdata, and consideration is being given to tying Viewdata in with the Telex network so that messages can be passed back and forth between the two. Private files are to be included in the system, with access allowed only to authorized people.

The success of Viewdata and Teletext will depend heavily upon the cost of adapting the TV receiver. If the demand is great enough, the necessary large-scale integrated circuitry can be produced fairly cheaply as an integral part of the TV set. Otherwise, a separate adapter will be needed, preferably connecting directly to the video circuitry of the TV receiver so as to avoid the need for a UHF modulator and, in the case of color, the very complicated circuitry required to generate the chrominance signal. (For historical reasons British VHF TV has a 405-line raster, color with 625 lines being confined to UHF.) The adaptation of black-and-white sets is much easier, as they are now often supplied with a video input for connection to a tape recorder, but color sets lack external jacks for the three video inputs that are easily generated by Viewdata to produce its range of 7 colors (indicated by a control character preceeding the material to be given a particular color; characters can also be made to flash repeatedly on and off for emphasis). In any case, the set would still be able to receive TV programs, and this would be a selling point for homes, but perhaps not for offices.

The Pye Company has begun selling Teletext adapters to the public for color TV sets at a price of £395 ($675) through Harrod's department store in London. Because it is interactive, Viewdata needs more time to set up facilities for handling large numbers of users and it may become available to the public in 1979. Together, Teletext and Viewdata offer many attractive features, and they could even do something to stem the tide of paper that is inundating us

all; but alas, devices for producing hard copies will eventually be manufactured at low-enough prices to result in their frequently being incorporated into the system. (Nelson M. Blachman)

TECHNOLOGICAL INNOVATION IN THE UK--A CASE STUDY

One of the latest attempts in the continuing effort of British research groups to diagnose the maladies of the UK's manufacturing industry is the recently published research report entitled "Technological Change, Structural Change and Manpower in the UK Toolmaking Industry". This is one of a series of reports on the toolmaking industry published over the past several years by the Science Policy Research Unit (SPRU) at the University of Sussex. Copies of this report are obtainable from EITB, 54 Clarendon Road, Watford, Bucks., WD1 1LB, England. (The organization and activities of SPRU were described by E.I. Salkovitz in ESN 24-12:387-390.) Financial support for this and previous projects dating from 1968 was provided by the Engineering Industry Training Board (EITB), whose main objective is to understand better the relationships between R&D policies, industrial innovation, productivity growth, and international trade performance.

During the 1950s and 1960s, it was widely believed that automation would have a dramatic impact on employment in certain of the UK's key manufacturing industries. The SPRU, in the late 1960s, identified the toolmaking industry as one in which very substantial employment dislocations were likely to occur as a result of innovation: namely, the introduction of numerically controlled (NC) machine tools such as automatic milling machines, drafting machines, drills, etc.

The SPRU's definition of the "toolmaking industry" is somewhat vague, perhaps of necessity. In essence, the "industry" includes those manufacturing operations whose products are the tools which are themselves used to form materials into shapes in subsequent "component manufacture" processes. Typical products of the toolmaking industry are forming-tools such as sheet-metal presses and diecast molds, as well as jigs and fixtures which permit a particular set of manufacturing operations to be carried out more accurately and rapidly by attachment to a general-purpose machine tool. Inasmuch as the output of the toolmaking industry consists of the tools needed by the manufacturing industry to produce end products, toolmaking clearly plays a central role in the UK's economic well-being. Indeed, many economists use current new orders in tooling as a key economic indicator.

At the beginning of their studies in the late 1960s, the SPRU group hypothesized that the following would take place in the UK toolmaking industry: "We expect that technological change will tend to lead to significant concentration of toolmaking into fewer establishments resulting from: (a) concentration by larger firms of their toolroom facilities into fewer locations, in particular those locations where the most sophisticated production equipment is installed, and (b) a decline in the number of small independent toolmaking firms which make the more 'routine' types of tooling."

This statement of SPRU's early expectations for the UK's toolmaking industry is a remarkably accurate prediction of what actually did happen in the automotive sector of the American toolmaking industry which has now automated nearly all of its design, drafting, model-making and die tooling activities. In the process, there indeed were major job dislocations of thousands of draftsmen and other skilled employees. Some, whose jobs were made obsolete, were retrained into allied skills within the new technologies, while others were forced to find employment outside the industry. The specific technologies which were responsible for this innovation were computer-aided geometric design (CAGD) and numerical control (NC). CAGD involves the use of recently-developed mathematical techniques for the computerized representation of free-form surfaces such as automobile, ship and aircraft exteriors. When CAGD techniques are used to cast design information into computerized form early in the design process, most of the subsequent tasks of "body drafting" and "body engineering", which traditionally required virtual armies of skilled draftsmen,

template-makers and 3-D model-makers, can be automated by the use of NC technology.

Contrary to their early expectations and the hypotheses upon which their previous studies were based, the SPRU investigators discovered a notable lack of innovation in the British toolmaking industry. Instead of serving as a model for studies of technological change and its consequences, the SPRU report concludes that "there are important barriers to a rapid rate of technological change in toolmaking" (in Britain). These barriers are seen to be:

1) Company managements are reluctant to revise conventional manufacturing techniques.

2) The diversity of the products of a given tool and die manufacturer tends to create difficulties in the application of CAGD and NC.

3) Features such as digital readout displays improve the productivity of conventional machines and somewhat reduce the human skill required at much less capital cost than NC equipment.

4) British managers consider the risks and capital investment required by the CAGD and NC techniques of "automated toolmaking" to be too high.

5) The demand for tooling is cyclical. Thus, in slack periods new investment cannot be afforded; in heavy demand periods, there are significant risks associated with technological change and the attendant problems of reorganization and retraining of the workforce.

In brief, the SPRU report comes to the discouraging conclusion that there appears to be *insufficient economic incentive* for innovation in the British toolmaking industry. No one familiar with the contemporary socio-political-economic conditions in the UK can be surprised by this conclusion. Widespread government subsidies of inefficient industries, the virtually confiscatory taxes on personal incomes and corporate profits, the British manager's constant fear of provoking production-stopping "industrial action" by volcanic union leaders, and the present Labor Government's efforts to further its so-called "Social Contract" by the enactment of more industrial democracy legislation aimed at greater worker participation in business decision-making are some of the factors which dampen British industry's enthusiasm for change and innovation.

In a recent analysis of British science and technology, Sir Alan Cottrell (Master of Jesus College, Cambridge, and former Chief Scientific Advisor to Her Majesty's Government) stated: "Industry has now almost run out of money, so that the level of investment in new factories and machines has dropped to only about half what would be needed merely to keep our firms up to the technical level of our principal competitors. Much of the country's research and development is thus fruitless because industry cannot afford to take advantage of the opportunities it throws up."

Perhaps all this helps to explain the results of another recent study entitled "Managing Manufacturing Operations" sponsored by the British Institute of Management in conjunction with the London Business School and the British Production and Inventory Control Society, summarized by a headline in the Business News section of the London *Times* for 6 December 1976: "Survey finds only 3% of British manufacturers deliver on time."
(William J. Gordon)

NEWS & NOTES

A "BRITISH BROOKINGS"?

Before the end of 1977, London may have a "policy institute" modeled after the Brookings Institute in Washington. The purpose of the "British Brookings" would be to bring together policy-makers and academics to examine the economic and social difficulties facing Britain. It would have a permanent head, a board of 10, and up to 80 fellows and visiting fellows. The institute would be located within easy reach of Westminster and Whitehall.

The principal advocate of the "British Brookings" is Professor Ralf Dahrendorf, Director of the London School of Economics, a trustee of the Ford Foundation and a former EEC commissioner. Dahrendorf is confident that the £1 million ($1.8 million) per year required to support the institute can be raised from British, European and American sources.

EEC ASSAULT ON IBM

"Almost by definition" says the London *Times*, "what is good for IBM is bad for Europe." In an attempt to muster a viable European threat to IBM's market dominance, the EEC recently proposed a £43 million ($75 million) four-year program of financial support for the European data-processing industry. Under a so-called Community Premium Scheme, support would be provided for the software industry, the minicomputer and peripheral sector of the hardware industry, and the electronic components sector.

ACUPUNCTURE AT EDINBURGH

Experiments at Edinburgh University's Department of Psychiatry support Chinese claims that insertion of acupuncture needles into specific points of the skin can alter sensation in widely separated parts of the body. Carefully controlled tests carried out on 12 volunteers showed that needles put into the arm and leg reduced pain sensation in the region of the stomach. The investigators claim that the effect could not have been due to suggestion and that the conclusion must be that acupuncture may relieve pain sensations.

PERSONAL

Mr. Handel Davies has been elected President of the Royal Aeronautical Society for the year 1977-78 and Professor L.F. Crabtree to be President-Elect. Both will take office at the conclusion of the Society's Annual Meeting in May.

Mr. B.T. Robson, Lecturer in Geography, Univ. of Cambridge, has been appointed to a Chair of Geography at the Univ. of Manchester, from 1 October, in succession to Professor T.W. Freeman.

OBITUARIES

Professor W.R.D. Jones, Emeritus Professor of Metallurgy at University College, Cardiff since 1961, died on 25 January at the age of 81. His research work was directed largely towards light alloys containing magnesium. He determined the copper-magnesium phase-diagram in 1932. During his many years at University College, he held many posts other than being head of his department.

Professor R.A. Morton, FRS, Emeritus Professor of Biochemistry at the University of Liverpool, died 21 January at the age of 77. In 1944 he was elected to the Johnston Chair of Biochemistry, the first established chair of biochemistry in the UK. In his early research, Morton pioneered the application of absorption spectroscopy to biology. In later years, he discovered two new groups of compounds, the ubiquinones and the polyrenols. Even after his retirement in 1966, he continued his research and published a second edition of his two-volume book, *Absorption Spectra of Vitamins and Hormones*, which was first published in 1942, as well as a history of the Biochemical Society.

Professor William Muckle, FRINA, FIMarE, who was Professor of Naval Architecture at the Univ. of Newcastle upon Tyne until his retirement last fall, died 7 January at the age of 65. He was best known for his work on ships' structures and the use of aluminum alloys in ship construction. He was the author of two books, *Strength of Ships' Structures* (1967), which became a standard university and college textbook, and *The Design of Aluminum Alloy Ships' Structures* (1967).

ONRL REPORTS

R-11-76 FRANCE'S GRANDES ECOLES by A.I. Barcilon

A review of the characteristics of a unique system of higher education found in France: The "Grandes Ecoles". The report looks in some detail at the engineering schools in France and provides an overall view of French engineering.

R-12-76 ELECTRONIC AND TELECOMMUNICATION ACTIVITIES IN EGYPT by D.K. Cheng

This report summarizes the existing and planned activities in the field of electronics and telecommunications in Egypt. Activities in the research, industry, and service sectors are described separately and some proposed future plans are given. A description of a planned Pan-Arab space-satellite network is also included.

R-13-76 OBSERVATIONS ON EUROPEAN LOW-TEMPERATURE PHYSICS RESEARCH: AN ANNOTATED DIRECTORY OF LOW-TEMPERATURE PHYSICS IN BRITISH UNIVERSITIES AND SOME COMMENTS ON THE LOW-TEMPERATURE PHYSICS PROGRAMS IN EUROPE by T.A. Kitchens, Jr.

This report summarizes the author's observations on low-temperature physics research in Europe during the period of August 1975 - August 1976. It features an annotated directory of the low-temperature research in British universities, and contains comments on visits to Continental institutions, both of which supplement ONRL Report D-15:1973 "Directory of European Low-Temperature Research" by E. Edelsack *et al*. Emphasis in the comments is on refrigeration and low-temperature components rather than on superconductivity.

R-14-76 OBSERVATIONS ON PSYCHOLOGICAL RESEARCH IN NINE BRITISH UNIVERSITIES by J.W. Miller

This report describes the results of visits to the psychology departments of nine universities. A brief survey of interests in the social sciences in the UK is included. The information is grouped into five categories: Ergonomics, Aids for the Handicapped, Vision and Perception, Man-Computer Interaction, and Other Areas of Psychology. In addition to describing specific psychology departments and research programs, comments are made about the direction of psychology in the UK and where, in the opinion of the author, its weaknesses and strength lie.

C-33-76 SACLAY CONFERENCE ON DIFFUSION IN CONDENSED MEDIA by L.M. Slifkin

This report on the 19th Colloque de Métallurgie, held by the Institut Naturial des Sciences et Techniques Nucleaires in June 1976, briefly summarizes the review lectures and focuses attention on the main results reported in the poster sessions. A picture is thus given of the rather extensive interests and developments in France in the general area of diffusion in solids.

C-34-76 IEE INTERNATIONAL CONFERENCE ON MILLIMETRIC WAVEGUIDE SYSTEMS by N.M. Blachman

This report summarizes a symposium on the use of circular waveguides for the long-distance transmission of telephone and related traffic. Conference sessions were devoted to overview papers, waveguide design and production, routing and laying, characteristics of installed waveguides, rf multiplexing, repeaters, active components and devices, systems aspects, and an open forum. It served principally as a forum for the presentation of the work of six countries--France, West Germany, Italy, Japan, the US, and the UK--and it included a visit to the UK Post Office Research Centre.

C-35-76 VIGILANCE REVISITED by R.R. Mackie and J.A. Nagay

This report summarizes a meeting held in St. Vincent, Italy (Aug. 1976) in which 65 specialists from 14 countries discussed and presented papers on "Relationships among Theory, Physiological Correlates, and Operational Performance". Problem areas considered included vigilance decrement encountered during the operation of ground and airborne vehicles, sonar and radar systems, industrial equipment, and a variety of other situations. Comparisons were drawn between the findings of laboratory and field experiments particularly as the emphasis has shifted during the past few years to field studies.

C-36-76 XIII INTERNATIONAL CONGRESS OF INTERNAL MEDICINE, HELSINKI, FINLAND, 15-19 AUGUST 1976 by M. Stek

This conference was divided into several main sessions focused on the role of bile acids in clinical and iatrogenic disease. These were combined with parallel and free papers devoted to a wide range of subjects in internal medicine. Sessions of particular interest dealt with infectious disease and clinical immunology.

C-37-76 LATTICE DEFECTS IN IONIC CRYSTALS: REPORT OF 1976 BERLIN CONFERENCE by L.M. Slifkin and J.H. Schulman

Salient problems and recent progress in the study of lattice defects in ionic solids were covered by excellent tutorial reviews and numerous contributed papers. This report gives a general overview of the meeting and briefly summarizes a large fraction of the papers.

C-38-76 POSITRON ANNIHILATION: FROM QED TO NDT by A. Sosin

The use of positron annihilation as a tool is showing a remarkable growth in a number of areas: chemistry, materials science, biology, etc. The Fourth International Conference on Positron Annihilation, held at Helsingor, Denmark, on 23-26 August 1976 brought together investigators from each of these areas, as well as those in positron physics itself. This report summarizes the presentations at the meeting and attempts to emphasize the highlights of the developments in the field of positron annihilation. As a preliminary to the conference review, this report also

C-38-76 (Cont'd) provides an introductory survey of positron physics and experimental methods for readers largely unfamiliar with positron annihilation.

C-39-76 INTERNATIONAL CONFERENCE ON RADIATION EFFECTS IN SEMICONDUCTORS by N.D. Wilsey and J.H. Schulman

Selected papers given at this Conference are briefly reviewed. The meeting emphasized how much is still unknown concerning the nature of defects in semiconductors other than silicon, as well as the need to develop other microscopic probes for investigating materials that are not readily amenable to ESR studies.

C-40-76 INTERNATIONAL CONFERENCE ON HYDROGEN AND ITS PROSPECTS by W.G. Soper

Papers from the International Conference "Hydrogen and Its Prospects" Liege, Belgium, 15-18 Nov 1976 are reviewed for their contribution to future production and utilization of hydrogen as a fuel. Principal emphasis is placed upon the production of hydrogen by electrolysis and thermochemical decomposition of water, and upon the comparison of these processes with synthetic fuel production from fossil resources. Other topics discussed include hydrogen storage and its use as fuel in automobiles and aircraft.